THE TELEGRAPHIC JOURNAL AND

Electrical Review.

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THE SPIEL PETROLEUM ENGINE.

FROM a letter which appears in our Correspondence columns it seems that an injustice, real or imagined, has been inadvertently perpetrated upon a valuable invention, directly by a financial contemporary, and indirectly by ourselves. As far as we are concerned, our views on the petroleum engines of both Eteve and Spiel are too well known to need any recapitulation, for we have always strenuously advocated their employment, and we consider it in no small degree due to the early publicity given to these simple motors in our pages that public interest in their performances has evinced itself to such a considerable extent.

Of the first-mentioned engine little or nothing is now heard, for reasons which we do not pretend to unravel; but that the latter is making headway there is no reason to doubt. We have now before us a list of testimonials which have been sent to Messrs. Shirlaw and Co., the manufacturers, from which it appears that quite a number of engines are satisfactorily in operation. No one can feel more gratified than ourselves at the result of Messrs. Shirlaw's labours, achieved in a period of time none too long for the development of a new invention, and we desire to accord them the credit they undoubtedly deserve for their skill and energy.

Whatever motive may have induced our financial contemporary to insert the note which we reproduced certainly does not apply to this journal, which is only interested in placing before its readers those items of news which have a bearing upon topics associated with matters electrical, whether the criticisms levelled against the object under discussion be favourable or the reverse.

In a letter published in Wednesday's issue of our contemporary, the legal advisers of Spiel's Patent Petroleum Engine Company, Limited, go so far as to assert that the paragraph in question was inserted purely with the object of injuring the company, but such does not seem to be the case, for *Money* retorts in these words:—"It appears that we have innocently given publicity to a statement with regard to the above undertaking which is not in accordance with facts. We much regret having done so; but to write furious letters, making sweeping and groundless charges, accusing us of publishing malicious and defamatory libels is, to say the least of it, simply absurd."

Royal Society.—The Bakerian Lecture, delivered last night by Professor J. J. Thomson, F.R.S., was on "The Dissociation of some Gases by the Electric Discharge." Professor W. Crookes, F.R.S., was announced to read a paper on the same occasion on "The supposed 'New Force' of M. J. Thore."

AT LAST.

WE are positively assured that on Wednesday next the Electric Locomotive and Power Company will commence its operations on the North Metropolitan tramway between Stratford and Manor Park. Alternately with horse cars, Mr. Elieson's electric locomotives will divide the passenger traffic on this line, and a long expected and much criticised experiment in electric locomotion will commence in downright earnest. For the first week only two engines with cars attached will be employed, but in the week following the carrying capacity will be doubled, so that the trial, which is to prove that tramcar propulsion in large cities by means of accumulators, and on lines already laid down, can or cannot compete on favourable terms with horse traction, will be a thoroughly complete one. The number of horses displaced by four engines is no less than forty-four, each car being provided with eleven, one of which is a spare animal—indeed, the poor quadrupeds are all spare enough after a year's experience in the London streets—the daily work of a pair of horses being 3¼ hours.

General Hutchinson and Major-General Armstrong have passed all the necessary requirements of the Board of Trade, and the licence necessary for commencing work, the non-receipt of which has up to the present occasioned a little delay, has now been granted, and no further delay will be entailed. The upshot of the trial will be awaited with the greatest interest, not only by the electrical fraternity, but by the public generally, and when we say that the computation of the running expenses has been placed in the hands of a well-known firm of accountants, it will be understood that a correct estimate of cost will be forthcoming. For our own part, we have little doubt as to the result; electrical traction must inevitably take precedence of horse-flesh, both from an economical point of view, and also from that of convenience in large towns.

The Electric Locomotive and Power Company has not been formed for the purpose of Stock Exchange gambling; it has had a definite object in view from which the directors are not likely to swerve, and the outcome of the company's operations is now, we hope, on the verge of success. When once it has been demonstrated that the traffic on the North Metropolitan tramway can be efficiently and economically carried on by means of electricity, we shall see an extension of electric traction in this country on a scale proportionate with that which is now going on in the United States.

A Congregation Dispersed by Gas.—The Galashiels Free Church congregation had a singular experience on Sunday forenoon. A meeting had been held in the church hall on Saturday evening, and in turning off the gas in the hall it was turned on in the church, and was escaping all night. Fortunately, when the church was opened in the morning there was no explosion. Every effort was made to clear the place of the fumes of gas, and the congregation assembled as usual. But the smell was so strong that the service had to be given up, and the congregation dispersed.

INSULATED CONDUCTORS.

By DAVID BROOKS.

IN the first attempt in America to work the electro-magnetic telegraph, by Professor Morse, he covered the wires with cotton, then soaked them in a preparation of shellac and then drew them, four together, into lead pipes. The intervening space was left empty. This system was laid from Baltimore towards Washington for about five miles on the Baltimore and Ohio Rail Road.

I get this information from Messrs. Tatham and Brothers, who made about thirty-five miles of the pipe, inserting the wires as the pipe was made. The experiment was a failure. About that time, or a little before, Professor Jacobi, of St. Petersburg, undertook to lay copper conductors covered with cotton and enclosed in lead pipe, filling the intervening space with rosin.

There were very many attempts of that kind which proved to be failures, until the year 1856, when the discovery of petroleum brought paraffin into the market as a cheap commercial product.

This was brought to my notice, and I made many experiments to test its insulating properties, and the result was, that it was taken to the Patent Office, and the patent awarded to me, broadly, for its insulating properties.

It occurred to me that cotton covered wires could be drawn into lead pipe and a useful system for underground purposes accomplished; but, before running to the Patent Office, specimens were buried in the yard of my factory directly under a body of water, or earth soaked with water from a hydrant. These experiments were repeated, and for a long time were attended with failure.

In the Journal of the Society of Telegraph Engineers, published in London, we find accounts of similar experiments made then with like results.

Sealing the ends of a portion of this leaded cable, coiling it up, immersing it in melted paraffin and raising the heat to about the boiling point of water, we noticed bubbles coming out apparently from the lead. Continuing this heat until all bubbles ceased to rise, and then testing the cable, we found the insulation restored. The inference was brought to my mind that the coiling and uncoiling of the lead pipe produced such molecular changes in the metal as to make it sufficiently porous to admit moisture, and the many unsuccessful attempts to lay lead covered cables, where the cables were insulated with paraffin, in deep water, have served to strengthen this impression.

It must be borne in mind that paraffin, rosin, asphalte, and other similar substances in their normal condition are brittle, and the coiling and uncoiling of the lead pipe breaks them into innumerable small fragments which would leave the cable full of cracks and crevices. These circumstances suggested the use of oil, and that brought out my system of iron tubes, on account of their cheapness.

Lead covered cables are now successfully made by having the insulating material, either rosin, asphalte, or pitch, mixed with oil in sufficient quantity to make the material plastic and capable of bending without fracture. Some of the inventors of these mixtures state that their insulating material is a secret. Other mixtures are the subject of patents.

Asphalte, rosin, or pitch, mixed with oil sufficient to make them plastic are heavier than water and thereby a great advantage is gained. Paraffin, either solid or liquid, is lighter than water. If solid, it cracks—if liquid, a drop of water penetrates it by reason of the greater specific gravity of the water.

In pursuance of the foregoing remarks, we must now look at the advantages of lead covered conductors for all kinds of indoor purposes, or what are commonly called distributing purposes for electric lighting, &c.

An ordinary cotton-covered paraffin conductor for inside work is a dangerous thing. There has been sufficient property destroyed by the use of these cheap articles to pay five fold for the substitution for them of lead-covered conductors.

A lead-covered conductor, No. 18 gauge, will show an insulation resistance of 10,000 megohms per mile. When used for inside purposes, if the lead covering is attached to a gas or water pipe, there is perfect safety from fire from the electric current should the outside conductor come into contact with an arc light conductor.

A conductor, 00 gauge, for arc lighting can easily be insulated when covered with lead to an insulation resistance of 500 megohms per mile, and when that is brought into a building for distribution purposes, and the lead covering attached to a gas or water pipe, there is perfect safety from fire from the electric current, such as occurred at the Temple Theatre in Philadelphia. Again, we can scarcely see how persons could be injured by the electric current conveyed through an insulated conductor covered with lead pipe in the manner that one of the employés of the Brush Company in this city was killed not two weeks ago, or, as another person was killed since then in the Adams Express building in New York.

Mr. J. N. Miller, of Cincinnatti, has referred to several instances where people have been killed by taking hold of the electric light conductor covered with what is known as the underwriters' insulation, which is simply no insulation at all when exposed to dampness. As this insulation cannot be made to burn with a lighted match, it has been supposed to possess great elements of safety. But when it is encased in lead and used for incandescent or arc lighting, a great portion of the current passes through the "insulation" to the lead covering. Taking a piece of this underwriters' insulated wire covered with lead and testing the insulation with a Holtz machine from wire to covering, you can produce no disruptive discharge, because the current passes through the "insulation," quietly, as fast as you can generate it by the machine.

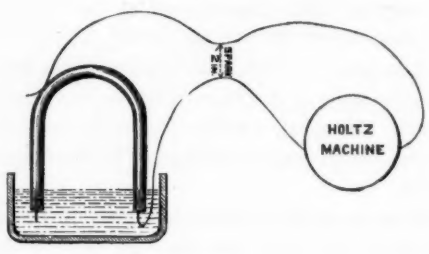


FIG. 1.

Take a similarly constructed lead covered cable properly insulated, immerse both ends of it in the insulating mixture, and pass a current from a Holtz machine having a naked conductor connecting one pole with the lead covering of the cable of the other pole, similarly connected with the encased and insulated conductor, a spark 2 inches long will pass between the two conductors in the air before any passes between the lead covering and the conductor within it, although the distance through the insulation is but $\frac{1}{8}$th of an inch (Fig. 1.). The object in immersing the terminals of the encased cable in the insulating material is to prevent short circuiting through the air from copper to lead at the terminals.

Much has been said of the incombustibility of the underwriters' insulation. But it is no more incombustible than the proper insulation, provided the disruptive discharge is not exposed to the air. We can make a disruptive discharge through the insulation if

it be too thin, but no combustion takes place, because the air is excluded.

We can now compare this insulation with gutta-percha, caoutchouc or their compounds.

Exposed to the air or buried in the earth, a lead-covered conductor will last more than ten times as long. Besides, when running these gum-covered conductors around a sharp corner, the insulating covering is apt to open upon the outside of the bend, while a lead-covered conductor will stand much rougher usage.

This quality has been demonstrated by a lead-covered cable for telephone and telegraph, armoured with heavy iron wire, and placed in the Delaware river between Philadelphia and Camden seven years ago, where it has worked without interruption or deterioration for all that time, although occasionally hooked up by anchors and doubled upon itself. Other cables laid in the same locality have had frequent interruptions, some have been entirely destroyed and replaced by similar ones, which have perished in their turn, and, for aught I can say, the process is going on. However, there is another class of electrical engineers coming upon the stage who do a little of their own thinking, and they have found out that there is both economy and good service attained by more recent devices.

There has been one objection to these lead-covered conductors, that the space at the *terminals* between the lead pipe and the conductor is so short that when exposed to a damp atmosphere moisture collects upon the surface of the unprotected insulating material and serves as a channel of escape of current from the conductor to the lead covering.

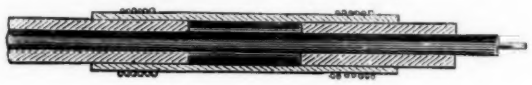


FIG. 2.

Messrs. Tatham and Brothers have a simple device by which that difficulty is completely remedied (fig. 2). A short section of the lead casing is cut out near the terminal, leaving some inches of the lead pipe undisturbed next to the terminal. An India-rubber sleeve is then slipped over the gap. Both ends of this sleeve are tightly bound to the lead pipe with twine, and the insulation of the cable is safe from moisture.

"IS ELECTRICITY MATTER?"

THE *Electrical World* of New York and the London ELECTRICAL REVIEW publish a letter by Mr. Carl Hering with the above title. Toward elucidating the question here put forward I venture to supply the subjoined small contribution. As I explained as far back as 1885 in the Vienna *Zeitschrift für Elektrotechnik*, the plexus of phenomena to which we apply the collective term "electricity" cannot be either solely energy *or* solely matter, but it must by all means consist of energy *and* matter, and for this reason—because any force stands in need of a medium (a lever or a connecting link) by means of which it can work. *Force without matter is unthinkable.* It is surprising that this fundamental law of the working of the universe seems unknown to the author.

Herr Aurel Anderssohn, President of the Physical Association of Breslau, and I, have, setting out from the researches of the astronomer Angelo Secchi, of Rome (see his work, "Les Forces Physiques") conducted experiments for years, and have finally published our resulting views, both in the "Annals" of the above-mentioned association and in the journal *Natur*, conducted by Karl Müller, of Halle.

The above-named association endeavoured in 1871, in the first place, to demonstrate the so-called attractive force of the earth. The attempt did not, however, succeed in any manner. On the contrary, the conclusion was reached that gravitation can consist only in the reciprocal pressure of the heavenly bodies upon each other, and that this pressure is propagated in space by means of an exceedingly subtile matter which we call ether. According to this conception the electric current is nothing but the flow of the ether in the metallic conduction. The plus or minus pressure forms respectively positive or negative electricity, and the inexhaustible mass-pressure of the numberless heavenly bodies existing in space supplies the fluid whose pressure, in certain of its manifestations, we call magnetism.

This view is very unwelcome to many professors, many of whom have scarcely yet digested Mayer's theory of heat. How, then, can they already again teach a new theory? This seems to me the main reason why the "ether theory" has hitherto found so few adherents. But it will and must find its way, because it agrees well with practice. It will enable our manufacturers to construct their dynamos with a clear knowledge of what they are aiming at, since they will no longer have to take an unknown agent into account. Does not Mr. G. Kapp's calculation with the aid of the lines of force fully involve the ether theory? Our dynamos will become much simpler and cheaper as soon as we regard the cause of magnetism not as attraction but universally as pressure from without, and thus arrive at new constructions.

In my above-mentioned deduction of electric phenomena on the basis of the views of Secchi, Maxwell, Anderssohn, and others, I have, indeed, also declared that electricity consists in the matter of ether, and that it must be elastic by reason of the aerial particles therein existing; but it appears plainly from the entire deduction that I designate as active principle the "*gravitation from above*," therefore, force and matter. Although the mathematician Euler about 125 years ago, in his "Physical Letters to a Lady," and after him many others, *e.g.*, Zöllner and Edlund, have referred to the ether in this respect, Herr Aurel Anderssohn and I must be regarded as the first who have published this view in a brief and compact form.

J. ZACHARIAS.

"T. S." writes thus to our New York contemporary:

"I was a reader of Mr. Carl Hering's speculations on the nature of electricity in your issue of April 23rd. He would give us the choice of believing it to be 'force' or 'matter.' Now this agent, the electricity which we are discussing, does work, and hence must possess energy. Any primary book on mechanics defines these terms, and 'energy' is not 'force,' neither is it 'matter.' Hence I would give as the broadest definition, 'electricity is *a* form of energy.' Permit me to remark here that in my experience there is a popular error in the conception of the terms *force* and *energy*.

"When we attempt to discuss, '*What* form of energy is electricity?' the real difficulty commences. Man has not a special organ of sense for its perception, but must study electricity by certain well-known physical effects. This much is certain,—Electricity is readily transformed into heat, light, sound, chemical energy and mechanical work. In each case a certain amount of electrical energy disappears, and simultaneously there appears an equivalent amount of energy in these other forms.

"Other forms of energy are sound, a wave motion of the air (also transmitted through solids and liquids); heat, molecular vibrations within bodies; light, a vibration of the 'luminiferous ether.'

"None of the motions are visible to the eye, and yet that these forms of energy do exist as these motions in the above-mentioned media can hardly be denied by any one conversant with the many and beautiful experiments adduced in proof. Though we may be able at present only to speculate concerning the motion or the medium in the case of electricity, yet many of its laws are very simple.

"There is less positive misconception of the nature

of electricity if we look on its laws simply as mathematical aids by which, if properly used, one may calculate the physical effects. I avoid as far as possible attempting to make any mental conception of what volts, coulombs, ohms, &c., are (except as a matter of speculation in an idle moment). A coulomb does not mean quantity to me in any ordinary sense of the word; but I remember that if a certain weight or quantity of metal is deposited on an electrode in an electrolytic cell, a certain quantity of electricity is said to have flowed through the cell. In such a case the coulombs are *measured* by a quantity of deposited metal. The watt-seconds = volt coulombs is a measure of electrical energy, and this product has a well-known mechanical equivalence. If electricity were matter, and a coulomb the unit of quantity, Mr. Hering ought to have told how many coulombs make an ounce. As regards the generation of coulombs, which seems a stumbling-block, a dynamo certainly generates electrical energy by the consumption of mechanical energy, and a lamp in circuit consumes electrical energy, which is converted into light and heat.

"Let me mention a simple experiment, in view of the assumption that electricity is matter. Put two lead plates in sulphuric acid (dilute) and connect five such cells *in series*, and charge with 100 coulombs. Then connect the five cells *in multiple arc*, and they will furnish a discharge of 500 coulombs. Here is a case in which, according to Mr. Hering's reasoning, the quantity did not stay there, but all passed through, and yet these same cells can subsequently give five times the quantity discharged.

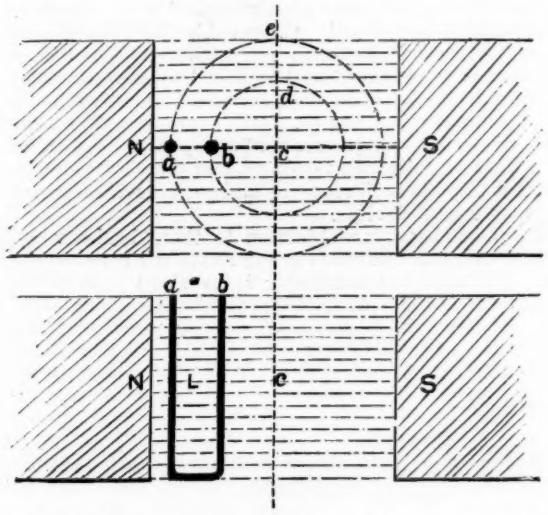
"As regards this 'What is electricity?' question, I have only taken the first step—indicated the nature of the problem—not tried to solve it."

NOTE ON MR. CARL HERING'S EXPERIMENTS ON GRAMME ARMATURES.

IN Mr. Carl Hering's article on "The so-called 'dead wire' on Gramme armatures," * some confusion has undoubtedly arisen, due to contemplating the same phenomena from two different points of view. The writer speaks of the E.M.F. as caused by (*a*) the cutting of lines of force by the rotating conductor, or (*b*) the threading of lines of force through the loops or coils enclosing the armature core, and proceeds in his article to treat these two probable causes as rival theories in conflict with each other. An experiment was scarcely needed at this date to show that a difference of potential is produced at the ends of a straight wire moving in a magnetic field, nor was it necessary to demonstrate that when the ends of such a conductor are joined a loop of some shape is formed which necessarily encloses the lines of force cut by the wire. These facts are perfectly well understood, and while we recognise that the E.M.F. produced is due only to the cutting of lines of force, in dealing with the looped conductor of an armature it is convenient to express this E.M.F. as proportional to the change in a given time of the number of lines threading through the loops.

Expressing the E.M.F. in terms of the increase or diminution of lines of force threaded through a loop need lead to no erroneous impression as to what parts of the loop are really active. The active parts are those cutting lines of force, and since viewing the question from this side commits us to no confusion regarding idle and active wire, the fallacy Mr. Hering refers to must lie not with the theory but with the interpretation he has given to it. If a loop is moved in a magnetic field *the number of lines of force cut, considering them as positive and negative with reference to the relative direction of induction in the two halves of the loop, is equal to the difference in the number of lines enclosed in the first and last position.* From this it follows that the result obtained for the E.M.F. is the same whether we consider it as due to the cutting of lines of force or as due to the threading of lines through loops; indeed, these are only two ways of making the same statement.

To illustrate this, let N and S represent two poles between which we have a uniform field. Let *a* and *b* represent the two parts of a single loop, L, such as would form one in a Gramme armature, and which is capable of movement about an axis, *c*. The position of the loop, as shown, corresponds with the horizontal line joining the centres of the poles. If it moves through a quarter of a revolution, *a b* will coincide with *e d*, and the lines cut by *a* = *c e*, and by *b* = *c d*. Since the E.M.F. generated in



b opposes that in *a*, the resultant E.M.F. produced is obviously proportional to *c e* − *c d*. But *c e* − *c d* = the lines of force now enclosed by the loop, which had no lines of force passing through it at starting. If the poles are shaped to a circle, and the loop wound on an iron ring so that none of the lines pass through the centre, *c d* = 0. But the number of lines cut by *a* in moving through a quarter revolution equals that enclosed by the loop at *e d*, since we assume that all the lines go into the ring. The number enclosed at *e d*, is the difference between the lines threaded through the loop in the first and last position, and it follows, therefore, that the phenomena observed in dynamos can be explained accurately, whether expressed as due to the cutting of lines of force or to change in the number of lines enclosed by coils. In this case the more convenient way of looking at the subject is probably the better. W. B. E.

* See ELECTRICAL REVIEW for last week.

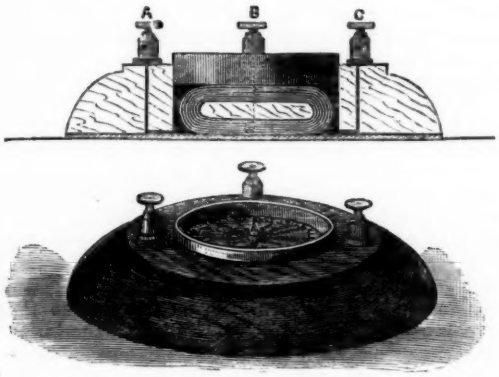
A SIMPLE GALVANOMETER.

A USEFUL and inexpensive galvanometer, as described by Mr. George C. Sonn in the *Scientific American*, may be constructed as follows:—

A hardwood base, a few inches in diameter and about an inch in thickness, carries a small pocket compass, set firmly into the base over a silk-insulated wire, the ends of which are attached to binding posts on the upper side. The writer has made a neat instrument at a cost of 80 cents—better than he could buy under $5. The compass may be bought at hardware stores for 30 cents. It is well for the purchaser to test the compass, before buying, with a magnet. Select the one that is swift to obey the influence of the magnet. Then mark out upon the upper side of the base the outline of the compass. With a knife sink the circle thus outlined an eighth of an inch, as a pocket for the compass.

Cut the wood so as to form a bobbin, upon which is wound wire, as shown in the upper sectional view. This should be laid carefully, one end being left for attachment to binding post, A, and the wire being

wound about the core by passing the other end through the openings, and then attaching it to the binding post, C. About 20 feet of good quality, silk-covered wire, of size between 26 and 32, is amply sufficient. After the wire has been wound upon the core there may be attached to it, with a little care, at its middle, a short piece that will connect with a third binding post, B. This will make a short circuit of one-half the length of the wire, when terminal A or C is connected with terminal B. A fine gimlet hole will serve to carry

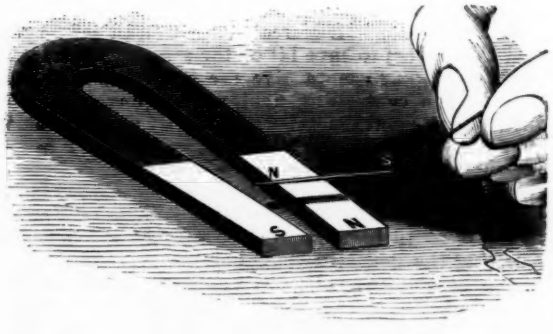


each end to its binding post, where it is best attached to the foot of the post, leaving the holes in the posts for other connections. A circular piece of tin may then be fastened to the base, so as to cover the wire, and the whole base may then be varnished or oiled to suit the fancy. The compass may be firmly united to its receptacle with a bit of Chatterton's compound or glue, care being taken to set it perfectly level.

An instrument thus constructed will be sensitive to delicate currents, and forms a useful galvanoscope for amateur and professional electricians.

EXPERIMENT IN MAGNETISM.

MATERIAL, a horseshoe magnet and a common sewing needle. Insert a light thread in the needle, tie, and cut off one end, leaving a single thread 6 or 8 inches



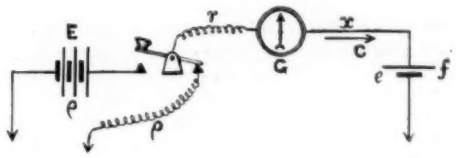
long. Lay the magnet on a table, with poles in front; magnetise the needle by rubbing it several times, always in one direction, by one pole of the magnet, after each stroke returning the magnet in an arc through the air. Take the end of the thread between thumb and finger, and suspend the needle over its attractive pole, allowing the point to come within one-fourth of an inch of the magnet, then, with a circular sweep of the hand, to keep the point in position, draw the eye of the needle down toward the other pole. This, if carefully done, writes Mr. William Salisbury in the *Scientific American*, will bring the needle to a horizontal position, where it will remain, floating or in suspension, as long as the thread is held steadily. The magnetic forces operating to produce this effect appear to be, first, the attraction of the left pole for the point of the needle; second, the repulsion of the right pole for the same point; and third, the attraction of the right pole for the eye of the needle, which is resisted by the thread supporting the needle; the latter also is held from approaching the left pole by the same means.

The editor of our contemporary says:—"It can be performed with quite a small magnet. A 2 inch magnet answers perfectly. In using a small magnet, the point of the needle should be broken off to reduce it in length. The thread may be held close to the needle; an inch length of free thread is enough. The experiment may be made more effective by covering the magnet with a sheet of paper, thus concealing it."

REPRODUCED DEFLECTION METHOD OF OBSERVING THE RESISTANCE OF A FAULT AND MEASURING THE CURRENT THROUGH IT.

By E. C. RIMINGTON.

Let E be the E.M.F. of testing battery;
„ ρ its internal resistance;
„ x the resistance of the cable to the fault;
„ f the resistance of the latter;
„ e the E.M.F. acting in it due to polarisation;
„ G the resistance of the galvanometer, and
„ r an adjustable resistance.



Let the deflection when the battery key is down be D (the galvanometer being a proportionally reading one). Then if C be the current

$$C = \frac{E - e}{\rho + r + G + x + f} = \gamma D$$

where γ is the reduction factor of the galvanometer. Release the battery key and let the deflection be d; d being in the opposite direction to D

$$\gamma d = \frac{e}{\rho + r + G + x + f}$$

$$\therefore \gamma (D + d) = \frac{E}{\rho + r + G + x + f}$$

Replace the cable by a resistance box and adjust to obtain a deflection, $D + d$, let R be the resistance which must be unplugged to do this. Then obviously

$$x + f = R$$

$$\text{and } \gamma = \frac{E}{\rho + r + G + R} \cdot \frac{1}{D + d}$$

$\therefore$ C the current through the fault

$$= \frac{E}{\rho + r + G + R} \cdot \frac{D}{D + d}$$

By altering r we can give different values to C.

The deflection, d, should be observed by reading three turning points of the galvanometer index in order to obtain the deflection due to e as soon after the testing current has ceased as possible, as the value of e will rapidly fall off.

PRACTICAL ELECTRICAL MEASUREMENT.

By J. SWINBURNE.

(*Continued from page* 464.)

Voltmeters and Ammeters.

Voltmeters and ammeters are so often the same instruments wound with different wire, that they will be discussed together. For the sake of simplicity, they will be divided into groups according to their principles of construction.

Permanent Magnet Instruments.—A very strong prejudice exists against the use of permanent magnets in measuring instruments. This prejudice is really unfounded, as a permanent magnet, if properly made in the first place, is constant enough for ordinary purposes, as it does not vary perceptibly from year to year, and the error due to its change is insignificant in comparison with the errors that are to be met with in many of the instruments now in the market.

Several physicists have carefully studied the "decay" of permanent magnets, A newly made magnet, especially if strongly magnetised, loses its magnetism quickly at first and then more and more slowly, till finally it remains practically constant. If it is not magnetised strongly to begin with, and is made of very hard steel, it is practically permanent from the beginning. Probably the chief reason why permanent magnets are not more generally used is, that as they cannot be patented, each maker prefers to push something else that can, and does so at the expense of permanent magnets and spring instruments.

The tangent is the best known form of the permanent magnet instrument. Sir W. Thomson's well-known "graded" galvanometers are tangent instruments in which the needle and controlling magnet can be moved nearer or further away from the deflecting coil. The needles consist of four little bars of hard steel. These are attached to an aluminium cap like that used in Sir W. Thomson's mariner's compass. The index is formed of two pieces of thin aluminium with their ends meeting to form the point of the index. The index is seen edgeways on looking down, and the aluminium is so thin that the instrument can be easily read. The scale is of paper, stuck to a piece of plate looking-glass. The controlling magnet is a semicircular piece of bar steel arranged as a hoop over the needle. One end can be adjusted by a screw if the needle does not come to zero. The needle is enclosed in a three-cornered box on which the controlling magnet also rests. This box rests on a short board of hard wood and slides to and fro, being guided by a groove in which one leg rests. The wooden slide is graduated according to the field produced at different distances from the coil. In a voltmeter the coil is of high resistance, that is to say, an instrument that will read up to 100 volts has a resistance of about 8,000 ohms. It has a ring of circular section; probably the object of this shape is to get the strongest field with the least waste of power and the least deviation from the tangent law. The ammeter is the same as the voltmeter, except that it has a smaller coil of copper strip. A length of twin cable with suitable clips is supplied with each instrument.

As these are expensive instruments and should be correspondingly accurate, they must be criticised somewhat exactingly. The writer had two for testing incandescent lamps. In these the paper scales were not quite accurate; in fact, the scales cannot be made accurate both for reading when the needle is right in the coil and when it is at the far end of the wooden platform, as the field due to the coil is not equally nearly uniform at different distances from the coil. The marks on the wooden base are so arranged that the magnet box cannot be accurately adjusted to them, as there is a groove along the middle of the wooden platform, and the front of the magnet box is slightly raised and is, moreover, curved. The best plan is to fasten a piece of thin sheet brass to the front of the box so as to touch the wooden slide. The slide can then be marked again and places found where the instrument reads directly in volts and ampères. Of course this really means recalibrating the instrument, but that is a small matter. The resistance of the voltmeter coil was either marked wrong to begin with in the instrument used by the writer, which is unlikely, or it had fallen. The voltmeter was supposed to be graduated in Rayleigh volts, but the resistance was correct in B. A. ohms. It is most probable that the resistance of fine wire coils in all voltmeters gradually falls, and that it was a mere chance that the reading came right in B. A. ohms. The controlling magnets were not permanent, being apparently too strongly magnetised. The writer demagnetised them and magnetised them again more feebly, and after a little they were practically constant. The magnets are not fixed on, and are apt to be knocked off or dropped. In use they must be tied on, and it is needless to say that if the magnet is dropped or knocked about the instrument must be calibrated again. When readings for very wide ranges are needed the graded galvanometers are very useful. When readings have to be taken all day, as in incandescent lamp testing, they are extremely valuable, as the resistance of the coils is so high that the voltmeter does not read much too low on account of the wire heating, and the ammeter is of no perceptible resistance, so that the voltmeter may be put in shunt to it and the lamp.

The most convenient form of tangent galvanometer is the skew instrument, in which the controlling field is not at right angles to the deflecting field. The controlling magnet may be placed at about 45° or 60° from its usual position. The advantage of this disposition is that the scale is spread out in the middle where most of the readings are taken. The scales for such instruments can easily be drawn or marked off geometrically, but it will generally be found that an instrument does not follow the tangent law throughout its scale, and is about 1 per cent. out at the high readings. After an instrument is made, three or four points should be carefully determined, and the intermediate points can be found by dividing the distance between the known points according to the tangent law. The error will be then quite imperceptible. The great drawback of all instruments that follow the tangent law, even approximately, is that the controlling and deflecting fields must be comparatively weak, and the instrument cannot be used in the neighbourhood of dynamos, or near wires carrying large currents. The troubles arising from dynamo fields have been greatly exaggerated; it would be of no advantage to be able to put a voltmeter on the field magnets of a dynamo and take a reading, but an instrument should be unaffected by a dynamo ten or twenty feet off.

In 1881 to 1882 M. Marcel Deprez and Profs. Ayrton and Perry seem to have hit on the same idea, viz., using permanent magnets to give the controlling field, and making the controlling field very strong, so that the instrument should not be affected by a neighbouring dynamo. The Ayrton and Perry permanent magnet instruments are too well-known to demand description here. These instruments had some very serious faults: the inventors made the controlling field so very strong, and left so little room for the wire of the deflecting coil, that the deflecting coil got hot very soon, which, in the case of the voltmeters at least, interfered with the accuracy of the readings. The magnets also became weaker with age. Prof. Ayrton says this was due to the keeper, which instead of preserving the magnetism, as is commonly supposed, weakens the magnets very quickly. In the later permanent instruments they have done away with the keepers. The early forms did not read directly, but were graduated in degrees, a constant being given with each instrument. The modern instruments are direct reading, but both early and later instruments are supposed to read proportionally, the pole pieces being filed into a particular shape which is supposed to effect this. It is needless to say that it is impossible to make such instruments read proportionally with any accuracy, and they would be better if the fields were weaker and if there were more room for the deflecting coils. The scales are short and so readings

cannot be taken with very great accuracy, but the instruments have some important advantages in being dead-beat, portable, and useful close to a dynamo. The early forms were all made by Messrs. Paterson and Cooper, now they are also made by Messrs. Latimer Clark, Muirhead & Co. The prices vary from £6 6s. to £9 9s. The higher price is for commutator instruments. The commutators multiply or divide the readings by ten, thus increasing the range, but they are apt to get out of order.

Deprez's voltmeter and ammeter is much the same as Ayrton and Perry's in principle, though different in form. It has the advantage of a larger reading, as the deflecting coil is set at an angle so as to give a large reading on one side and a small one on the other. Deprez's voltmeters and ammeters are made by Carpentier, and are used widely in France, though not well known in this country.

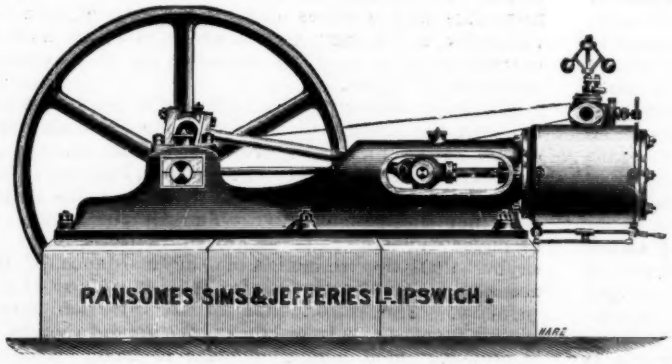
Messrs. Siemens make a permanent magnet instrument in which the needle is itself the standard magnet. The needle is of the form constantly used by Messrs. Siemens and Halske. It is a sort of long steel thimble, slit nearly its whole length, magnetised as a horse-shoe magnet. The object of this form of needle was originally to make a reflecting galvanometer dead-beat, but in this case it is difficult to see why that form is used, especially as a metallic vane is attached to damp the vibrations, instead of the usual copper damper. The needle is deflected by a pair of coils, and is brought back to zero by the torsion of a spring, much as in the well-known torsion dynamometers. This instrument has the disadvantage that it is not direct reading, and, therefore, that it takes longer to read it. It is, also, more a laboratory than a workshop instrument. It contains both a permanent magnet and a spring, but it must be remembered that if both weaken with age the error due to one tends to counteract that due to the other.

(*To be continued.*)

NEW QUICK SPEED STATIONARY ENGINE.

THE illustration represents a quick speed stationary steam engine which is now being manufactured by Messrs. Ransomes, Sims & Jefferies, Limited. It is made in three sizes: from 3 to 8 H.P. nominal, and is eminently adapted for export on account of the few parts employed in its construction. The engine bed-plate, cross-head guides, as well as the plummer blocks for crankshaft, are all cast in one piece; the cylinder, with its valve chest, being bolted to the end of the engine frame. These engines are also well adapted for electric light purposes, and when so employed the larger sizes may be fitted with expansion valves or with Messrs. Ransomes' patent automatic governor expansion gear, which is already well known, and has given such excellent results in connection with electric light work, both as regards regularity in speed and economy of fuel. The foundation plate is planed on the underneath side for facility of fixing. The engine has a flywheel of ample size and width for giving off the full power, and a force pump with brass valves and seatings, worked by an eccentric from the crank-shaft, is supplied when desired.

Steam may be supplied to these engines by any description of boiler, although those of the locomotive multitubular type will be found well adapted for most situations, and will be sure to give satisfaction, as they are most economical in fuel.



ELECTRO-MAGNETIC DRILLING AND RIVETTING MACHINES.

MR. F. J. ROWAN, C.E., of Glasgow, has for some time been at work upon machines which will perform electrically operations in connection with shipbuilding, which have hitherto been executed by the hands of a class of skilled workmen who, when a time of prosperity comes and business is brisk, are very much addicted to striking for higher wages, and so putting the shipbuilder to extreme inconvenience. Mr. Macmillan, the well-known shipbuilder, of Dumbarton, has afforded Mr. Rowan every opportunity of testing his machines practically and in the hands of the ordinary shipyard men. We believe Mr. Macmillan perfected and brought into operation in his yard the first, if not the only steam rivetting machine, at a time when his men struck work and threw him upon his own resources, and he has cordially taken up this invention of Mr. Rowan's, as no doubt other shipbuilders will also do, as promising to be a means of rendering the master's position less dependent upon the caprice of his men, or the dictates of their trades unions. A few days since, at the invitation of Mr. Rowan, we had the pleasure of seeing his machines at work upon the ship *Albania* in Messrs. Macmillan & Son's yard. The drill was first

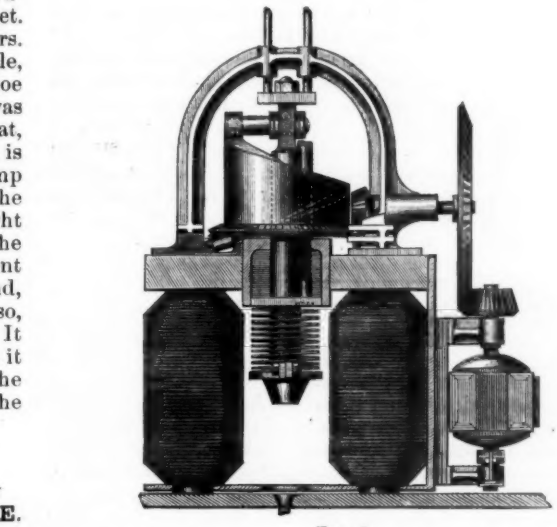


FIG. 1.
ELECTRO-MAGNETIC RIVETTER—MOTOR SEEN TO THE RIGHT.

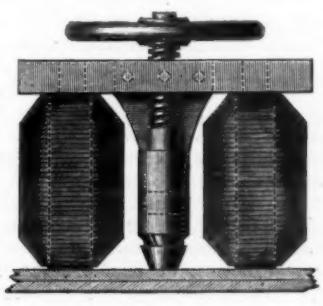


FIG. 2.
ELECTRO-MAGNETIC HOLDER-ON.

seen suspended by chains over a pulley at the ship's side and adjustable to the spots already marked where the holes were required to be made. It was understood, however, that the pulley arrangement was merely a temporary one, a traveller being provided for, which will enable the machine to be shifted both horizontally and vertically with perfect facility. The machine consists of three essential parts—a pair of electro-magnets to hold the whole apparatus to the plates of the ship, the tool itself, which is placed between the magnets and a half horse-power motor; the weight of the whole being about 4 cwt. The mode of operation is as follows—the magnets being brought into position so that the drill points exactly to the mark where the hole is to be made, current is switched on and the magnets attach themselves firmly to the ship's plates. The motor is next started, and by means of spur or bevel gearing reducing the speed of the motor, 1,600 revolutions, to about 150, the drill is revolved till the boring is completed, when the operator reverses the motion and the drill is withdrawn to its former position ready for a repetition of the process. The rivetter consists also of the same essential parts, namely, the holding on magnets, the hammer between the magnets and the small electro-motor of ·5 H.P., but, of course, is differently operated. The motor revolves a helical cam which alternately compresses and releases a spring surrounding and carrying the hammer. The striking force of this tool is said to be six times that of the heavy hammer now used by ship rivetters.

ALTERNATE CURRENTS.

By J. A. FLEMING.

THE communication from Mr. Rankin Kennedy, printed in the ELECTRICAL REVIEW of May 20th, is illustrative of the difficulties which are felt to exist on the subject of alternate currents, and also of the great assistance to be derived from a proper vocabulary.

The theory of alternate currents is no doubt a little more complex than that of steady currents, because there are two notions to grapple with instead of one. Dr. G. S. Ohm once for all endowed the world with the perfectly clear conception of electrical resistance as a quality pertaining to a given conductor in a given state as to temperature and steady flow. To talk of *apparent resistance* and *virtual resistance* is to sink down again to that region of confusion which contains such cognate terms as *virtual velocity*. Electrical resistance can never be anything else than real, and what is not real resistance should not be called resistance at all. Electrical resistance is, from one point of view, analogous to friction, a quality whereby an irreversible transformation of energy into heat takes place in the body resisting or at the rubbing surfaces. Electrical resistance, moreover, resembles friction in this respect, that just as friction requires the constant exertion of mechanical force to overcome it, so electrical resistance requires the constant exertion of electromotive force to overcome it, and produce in the one case motion and in the other case electric current. But there is another quality of matter, in virtue of which force is required to change motion, viz., its inertia or massiveness. To change velocity at a certain rate requires the constant exertion of a force proportional to the mass of matter moved. Similarly, to change current strength at a given rate requires the constant operation of an electromotive force proportional to a quantity called the self-induction of the circuit. The difference as regards energy between the operation of friction and inertia is that one is dissipative and the other conservative. The work done against friction is irrecoverably lost, but the work done against inertia is only stored. In the electrical analogue the work done against resistance is lost, the work done against self-induction or electro-magnetic inertia is recoverable again. If in any mechanical operation we find the effects of friction and inertia mixed up together—as in the operation of setting in vibration a heavy beam resting or balanced on stiff bearings—it is not proper to lump up both together and call it *virtual friction* or *apparent friction*. Similarly, where we allow an harmonically varying electromotive force to act on a circuit, setting up therein alternate currents, it is improper to call the ratio of impressed electromotive force to actual current the *apparent resistance*, because the effect to which this name is given is the resultant of three things—the real resistance, the self-induction, and the frequency of the alternations. It is the fashion now to raise a shout of protest against "new units," but it is tolerably certain that popular ideas on alternate current phenomena will never become clear until a name is found for this quantity, the algebraic expression for which is $\sqrt{R^2 + p^2 L^2}$, where R is the real or Ohmic resistance, L is the co-efficient of self-induction or the inductance of the circuit, and p is 2π multiplied by the number of complete alternations per second.

Mr. Oliver Heaviside has proposed to call this quantity the Im'pèdance of the circuit (accent on the first *e*), and the name seems very well suited for the purpose.

The impedance of a circuit is, then, a quality of that circuit which in all problems concerned with harmonically varying currents enters in in a manner analogous to that in which the Ohmic resistance is dealt with in problems of steady currents. That is to say, just as we obtain the strength of the steady current by dividing the real electromotive force value by the real resistance value, so we can calculate the mean value of the alternate current by dividing the mean value of the electromotive force by the impedance of the circuit. Now comes the point about which ambiguity generally occurs. Impedance is not resistance, and must not be mistaken for it, and it must not be called virtual resistance or apparent resistance or choking, or any such phrase, without doing violence to the proper use of the word resistance which is to express the dissipative quality of the circuit as regards the energy.

Impedance for a given frequency of alternations is measured in, or can be expressed by Ohms, and the student is therefore apt to say, why measure in Ohms that which is not properly a resistance? Generally speaking, the argument from *dimensions* does not come home sufficiently. We must therefore turn for help to an analogy. A condenser can be fitted with an appropriate commutator in such a way that the plates are short circuited periodically and then, as is well known, the condenser *plus* commutator can be placed in one arm of a Wheatstone bridge and measured as if it were a conductor having resistance. The condenser thus used does what a resistance coil does in one sense, it prevents or permits the passage of a certain quantity of electricity in a certain time. We can express the reciprocal of the product of the capacity of a condenser and the frequency of the commutation as the equivalent of a resistance, and it may be measured in Ohms. Generally speaking, whatever hinders the passage of electricity through a circuit can be imagined to be due to the substitution of a length of wire for that cause, and as far as such obstacle to the flow of current goes, it may be estimated as if it were a resistance in Ohms.

The inductance or self-induction of a circuit operates to limit the amount of flow which a given alternate electromotive force can produce in that circuit, its effect resembles resistance in one sense, but should not be confounded with it in nature, because the action does not dissipate energy. The simple theory of secondary generators is expressed in one phrase by saying that the reduction of the resistance of the secondary circuit reduces also the impedance of the primary. The introduction of an iron core into a circuit increases its impedance. We get rid thereby of statements about back electromotive force, which are all more puzzling than this one simple expression. It would be possible to work out a mechanical analogy by considering the case of a gyroscope compelled to move round an axis at right angles to its axis of rotation. The gyroscopic "stiffness" may be considered as equivalent to an increased friction, whereas its real origin

is in the inertia of the rotating mass. It would be mechanically a very imperfect way of expressing the behaviour of such a gyroscope to say that its apparent or virtual friction round that axis was increased by increasing its speed of rotation.

The true use of the term apparent resistance should be to express the changed resistance of a conductor subjected to very rapidly alternating electromotive forces when the rapidity of alternations is so great that the current never reaches its steady value distribution over the section of the conductor. Under these circumstances the resistance is really increased. In the same way, Maxwell first showed in 1865, the real resistance of a primary coil is increased by closing a secondary circuit near it. The inductance, however, is decreased, and the impedance, which depends both on resistance and inductance, is diminished.

REVIEWS.

Electro Deposition. By ALEXADER WATT. Second Edition. London: Crosby Lockwood & Co., 7, Stationers' Hall Court, Ludgate Hill.

The original edition of this work, which we noticed in our issue of February 12th, 1885, has undergone very little alteration in the course of republication; thus we find the extraordinary statement to which we called attention in the original review, viz., that "a dynamo having an electromotive force of 1 or 2 volts and a resistance of ·5 ohm may give a current of 800 or 900 ampères," again repeated. The comparatively short period which has elapsed since the first edition was published is a proof of the estimation in which the work is held, and the author may be congratulated on the success he has achieved.

Magneto and Dynamo-Electric Machines; with a Description of Electric-Accumulators. Translated from the German of Glacer de Cew, by F. KROHN. Second Edition, enlarged. With a preface and an additional chapter on the Latest Types of Machines. By W. B. ESSON. London: Whittaker & Co., 2, White Hart Street, Paternoster Square.

The original translation of this work has, in the new edition, been left untouched, the object being to enable a direct comparison to be drawn between the old machines and the new. The additional chapter from the able pen of Mr. Esson has greatly added to the value of the book, and it shows well the rapid progress which has been made in the construction of dynamos. The machines included in the new chapter are the "De Meriten's magneto-generator," the "Gordon generator," the "Ganz generator," the "Ferranti generator," the "Thomson-Houston dynamo," the "Brush dynamo," the "Raffard-Breguet dynamo," the "Goolden-Trotter dynamo," the "Manchester dynamo," the "Phœnix dynamo," the "Kapp dynamo," the "two-pole Gülcher dynamo," the "Crompton dynamo," the "Elwell-Parker dynamo," the "Gülcher multipolar dynamo," the "Victoria dynamo," the "Edison-Hopkinson dynamo," the "Elieson dynamo," the "Weston dynamo," the "Chamberlain and Hookham dynamo," and the "Thomson-Houston incandescence dynamo."

Lessons in Elementary Practical Physics. By BALFOUR STEWART, M.A., LL.D., F.R.S, Professor of Physics, Victoria University, the Owens College, Manchester, and W. W. HALDANE GEE, B.Sc. (Lond.), Demonstrator and Assistant Lecturer in Physics, the Owens College. Vol. II. Electricity and Magnetism. London: Macmillan & Co.

This publication is a most satisfactory one, and a most useful addition to our standard electrical works, and coming immediately after Prof. Ayrton's admirable "Practical Electricity," it forms a most useful supplement to the latter. In the first chapter the elementary phenomena and laws of electro-statics are briefly explained; we next (Chapter II.) have the fundamental laws of magnetism considered, and numerous experiments described, the student being directed how to make the same. Magnetic measurements are entered into at reasonable length and with considerable detail, with great advantage to the reader. In Chapter III. the fundamental laws and measurements of voltaic electricity are considered, and many practical hints are at the commencement given with reference to the setting up of batteries, the method of determining whether the porous pots are suitable for the purpose being explained; this is an important point, and it is one which often causes trouble. The attention which is drawn to details is a marked feature in the book, and greatly adds to its value. In speaking of galvanometers, the writers show how a very practical form of instrument may be made out of a tooth powder box, a compass needle, a sewing needle, some silk-covered wire, &c., in fact, an instrument which would delight the heart of Prof. Hughes. By the simple addition of a band of copper held by two binding screws, and by mounting the box on a board so that it can be slid along, it is pointed out that the principle of the Obach galvanometer and of the Thomson current meter can be exhibited. The whole chapter dealing with voltaic electricity is especially good, as indeed is the succeeding chapter which deals with resistance measurement; particular attention is here given to the use of the metre bridge, and the numerous ways in which it may be used are explained fully, the explanations being amplified by excellent diagrams, in fact, the whole subject of the Wheatstone bridge is very fully dealt with. The chapter following that on resistance has the tangent galvanometer for its subject, and the numerous uses to which this useful instrument can be applied are well explained. We next have excellent chapters on "The determination of the magnetic elements," "Electro-magnetism and electro-magnetic induction," "The condenser," "The electrometer," and finally an "Appendix." It is a great pity that the work is not provided with an index, as the "Contents" pages although fairly full are not sufficient for the purpose; a good index is a most essential addition to a technical book, and we are surprised that in the present case it has been omitted. In conclusion, we cannot too strongly recommend all those interested in electrical physics, and especially students, to procure a copy of the work, as it is undoubtedly one of the best of the kind yet issued.

ON THE MIGRATION OF IONS AND AN EXPERIMENTAL DETERMINATION OF ABSOLUTE IONIC VELOCITY.

By DR. OLIVER LODGE.

WHAT may be considered as the greatest step in advance since the time of Faraday in the subject of electrolysis is due to Prof. F. Kohlrausch. His idea of specific ionic velocity is obviously most important. The bases of it are his own experiments on conductivity, and those of Hittorf on "migration" or unequal concentration.

Up to the present time the numbers given by Kohlrausch for the absolute velocity of different ions in centimetres per second have been deduced from theoretical grounds only, and the sole verification to which they have been subjected has been by showing that from them the observed conductivities and migration coefficients of a considerable number of solutions can be calculated. In a paper published last year,* I indicated reasons for doubting the complete truth of the Kohlrausch theory as it stood, *i.e.*, for supposing it deficient in generality, and also initially suggested an experimental method suitable for examining the question, and for giving a direct determination of the absolute velocity of various ions, in a form apparently free from any hypothesis.

The method consisted in passing a current through an electrolyte contained in a uniform glass tube, and arranging some form of test substance to detect the position to which the ions had at any instant attained in their journey along the tube. The speed of any ion which lent itself to this mode of chemical detection

* Aberdeen British Association *Report*, p. 754.

could thus obviously be measured, provided disturbing causes could be excluded.

The experiments I have made on this plan hitherto, though numerous, can hardly be regarded as more than preliminary—a good many difficulties, some expected, some unexpected, having turned up in the course of the investigation, as usual. Nevertheless, a fair approach to a satisfactory and accurate result has been in some of the later instances obtained; and, besides the experience, some of the results themselves are worth having.

Let me first rapidly obtain the theoretical values of ionic velocity, in a complete manner, in order to distinguish the parts of the theory which are manifestly true from the parts which may require modification and development.

Consider a unit cube of electrolyte, containing n^3 *active* molecules, *i.e.*, n^3 molecules actually engaged in conveying a current, and ignoring any inert molecules such as those of the solvent have (perhaps without reason) usually been supposed to be. Let q be the total charge of each kind of electricity possessed by the constituent ions of each active molecule, and let υ be the velocity with which the two oppositely charged ions are being sheared past one another by the applied slope of potential $\frac{d v}{d x}$. Then, if k is the conductivity of the unit cube, we have the following couple of expressions for the intensity of current (*i.e.*, quantity of electricity conveyed per second through unit area normal to the flow):—

First $n^2 q \cdot n \upsilon$, from simple notions of convection;

second $k \frac{d v}{d x}$, from Ohm's law.

Writing N for the number of monad gramme equivalents *of the active substance* present in the unit cube, and η for the E.C.E. of hydrogen (that is, $1/\eta$ for the quantity of electricity corresponding to any monad gramme equivalent), it is plain that

$$\mathrm{N} \cdot \frac{1}{\eta} = n^3 q.$$

So, equating together the above two expressions for intensity of current, we get

$$\gamma = k \frac{d v}{d x} = n^3 q \upsilon = \frac{\mathrm{N} \upsilon}{\eta};$$

or,

$$\upsilon = \frac{k}{\mathrm{N}} \eta \frac{d v}{d x} = \frac{\eta}{\mathrm{N}} \cdot \gamma; \qquad (1)$$

γ being the intensity of current.

Whence the arithmetic sum of the opposite velocities of anion and cation (u and v), when urged by a slope of potential of one volt per centimetre, through a solution containing N monad gramme-equivalents of active substance per cubic centimetre and of specific conductivity k seconds per square centimetre, is

$$\upsilon_1 = u + v = \frac{k}{\mathrm{N}} \times \cdot 00010352 \times 10^8;$$

$$u + v = 10352 \frac{k}{\mathrm{N}} \text{ centimetres per second} \qquad (2)$$

So far the ground seems to me to be perfectly firm.

We now proceed to apply this to special cases. To do this we *assume*, with Kohlrausch, first, that $\mathrm{N} = m$, the quantity of salt in unit volume of the solution; second, that the ratios of the anion and cation velocities, u/v, are known for a number of substances from Hittorf's classical migration experiments. On these two assumptions a table of velocities can be constructed. They vary, it is true, with k/m, but this number is fairly constant for very dilute solutions of many substances; if it is not, the concentration must be specified.

The latest determinations of Kohlrausch give the following numbers for specific ionic velocities (in centimetres per second) in an aqueous solution containing one-tenth of a gramme equivalent of salt per litre, the applied E.M.F. being 1 volt per centimetre:—

Cation	H	K	NH_4	Na	Li	Ag	$\frac{1}{2}$Ba	$\frac{1}{2}$Mg	$\frac{1}{2}$Zn
$v =$	·00300	·00057	·00055	·00035	·00026	·00046	·00033	·00029	·00026

Anion	OH	Cl	I	NO_3	ClO_3	$C_2H_3O_2$
$u =$	·00272	·00059	·00060	·00053	·00046	·00029

Radicles omitted from this table, like SO_4, PO_4, &c., are intractable or anomalous.

Now in the above calculation what is there hypothetical? Accepting for the present the direct Hittorfian view of migration, the assumption that $\mathrm{N} = m$ involves two hypotheses, viz.:—

1. That the added salt alone is the active substance, the solvent conducting none of the current.

2. That the whole of the added salt is equally active.

On any dissociation view of electrolysis it could hardly be expected that when two substances are mixed one should be wholly inert, the other wholly active. It would seen much more probable, without evidence to the contrary, that the two substances should dissociate each other in some ratio or other, and that the conduction should be shared between them.

If this be so, equations (1) and (2) still remain perfectly true, but it is not so easy to determine N, the amount of active substance per cc. It may, indeed, turn out to be *proportional* to m, the amount of salt added, but it is hardly likely to be exactly *equal* to it.

Moreover, if two substances are active, we shall have to split up u into u_1 and u_2, v into v_1 and v_2, as well as N into N_1 and N_2.

If m is the mass of salt contained in every gramme of solution, $\frac{\mathrm{N}_1}{m}$ is the "dissociation-ratio" or "activity-coefficient" of the salt, and $\frac{\mathrm{N}_2}{1 - m}$ the dissociation-ratio of the water. And equation (1), written out fully, becomes—

$$\mathrm{N}_1 (u_1 + v_1) + \mathrm{N}_2 (u_2 + v_2) = k \eta \frac{d v}{d x} \qquad (3)$$

The value of k to be used here is the simple straightforward conductivity of the whole solution. There is to be no subtracting of hypothetical water conductivity in order to get at an inaccessible salt conductivity; the distinction between known and unknown quantities is perfectly definite.

By a complete quantitative electrolytic experiment, such as Hittorf first made, and Wiedemann and others have followed up, the four quantities $\mathrm{N}_1 u_1$, $\mathrm{N}_1 v_1$, $\mathrm{N}_2 u_2$, $\mathrm{N}_2 v_2$ can all be obtained; but it is not possible thus to obtain the values u_1, v_1, u_2, v_2, separately, unless the dissociation-ratios N_1/m and $\mathrm{N}_2/1 - m$ are known too.

The mode in which I have begun to make complete determinations of electrolysis may be stated for the case of copper sulphate. The cathode vessel is in the form of a specific gravity flask with a long horizontal tube neck, which has a constriction at one place, to which it can be accurately filled, and an open mouth above the constriction for the anode vessel to dip its beak into. The cathode can be a piece of platinum fused through the glass, or, more conveniently, passed through a stopper. The anode vessel may be like a tobacco pipe with anode immersed in its bowl, and its stem recurved so as to dip into mouth of cathode vessel. Only one of the two vessels is to have measurements made upon it, and the cathode vessel is perhaps generally the more convenient. It can be kept immersed up to its neck in a bath of water at constant temperature. (See fig. 1.)

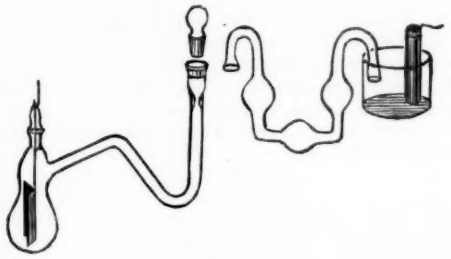


FIG. 1.

The course of experiment is as follows:—Fill cathode vessel with a standard solution, adjusting its level exactly to the mark at a known temperature; then weigh it. Pour a little more solution into its mouth. Fill anode vessel also with same solution; arrange as in figure, and pass a measured current for a known time, with a silver voltameter in circuit. Then remove anode vessel, readjust level in the other, and weigh again. Finally analyse the contents of the solution in cathode vessel, and weigh cathode deposit or voltameter plate. The necessary and sufficient data are these:—

1. Proportion of original ingredients in solution.
2. Initial weight of cathode vessel.
3. Final weight of ditto.

4 and 5. Any *two* of the following three things:—The amount of Cu, or of SO_4, or of free H_2SO_4 in the final solution.

The object of the long tube is to be sure that the current shall have to travel through the unaltered original solution in some part of its course.

I was under the impression that this scheme of experiment was more complete than any that had been previously attempted, but I have since looked up Hittorf's papers,* and found them very admirable. I do not say that nothing better can be done, but I have done nothing better yet, and, therefore, shall not at present rehearse the mode of treating the above data in order to extract from them their meaning, especially as it is long enough for a separate paper.

DIRECT EXPERIMENTAL DETERMINATION OF ABSOLUTE IONIC VELOCITIES.

Let us pass now from this rather laborious method of determining $\mathrm{N}_1 u_1$, $\mathrm{N}_1 v_1$, &c., to a simple and direct mode of experimenting on the velocities u_1 v_1 themselves. It is manifest that if one can determine for any substance Nu by one method of experiment, and u by another, its dissociation-ratio N/m, which must be a very important chemical constant, is known instantly.

One of the early forms of experiment for observing u and v was arranged thus:—

Two vessels, containing fairly strong sulphate of soda and baric chloride respectively, adjusted to equal density, were joined by a longish tube full of dilute hydrochloric acid of small specific gravity (fig. 2).

* *Pogg. Ann.*, Vols. LXXXIX., XCVIII., CIII., CVI.

A current from some 20 storage batteries was then applied, and the tube examined from time to time for the first appearance of a precipitate of baric sulphate.

When everything went well the precipitate appeared as a fine ring inside the tube, which rapidly filled up into a beautifully sharp thin disc or complete partition, and then grew in thickness, spreading out slowly both ways till it formed a solid plug and rather obstructed the current.

The locality of the disc and the time of its appearance after starting the current were noted, but I do not here record these first results because they were very variable, owing to disturbing causes.

FIG. 2.

One obvious disturbing cause is that of slight differences of level, produced either by earth warpings and local pressures, or by evaporation. To diminish mechanical changes of level the two vessels were next arranged side by side, and the tube was bent double so as to have its ends close together and yet to afford a good length for observation.

The level of the vessels was accurately adjusted, and the tube introduced with as little disturbance as possible, various devices, such as supernumerary tubes and stopcocks, being sometimes employed to assist this (fig. 3).

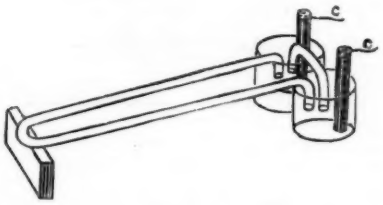


FIG. 3.

To diminish evaporation a layer of paraffin was sometimes put on each vessel, and my assistant, Mr. Robinson, hit on the happy device of connecting the two layers of paraffin by another and a much shorter and stouter siphon tube full of paraffin, so as to equalise the levels and, if possible, to keep them equal, and yet not to tap off any of the current by this supernumerary but also infinitely resisting path (fig. 4).

We now got much more consistent results, and for a long time thought things were pretty satisfactory, so we proceeded to make numerous observations, varying the character and length of the tubes, the number of volts applied, the strength of the solution, &c.

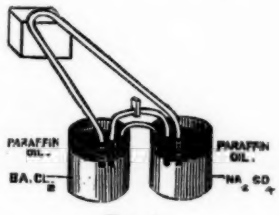


FIG. 4.

The difficulty of electric endosmose is an obvious one, and it may be owing to this that the results of these experiments are not very concordant. Omitting minor corrections, however, and taking the measured ratio of the distances of the ring precipitate, from the $BaCl_2$ vessel end, and from the Na_2SO_4 vessel end of the tube, for all those experiments where a paraffin levelling tube was used, we get the average result that the ring forms 3·2 times as far from the $BaCl_2$ end as from the Na_2SO_4 end.

This may be recorded by saying that the Ba travels three times the distance that the SO_4 travels in the same time, or that Ba travels three times as quick as SO_4; a result which, though simple and definite, is probably incorrect. But it is possible to argue that what we are measuring is not this simple ratio of speeds, but a more complex ratio depending on all the substances. Thus consider the substances in action

$$Na_2\ SO_4 \mid HCl\ HCl\ HCl \mid Ba\ Cl_2$$

and pass the current from right to left.

On Hittorfian principles, H travels to meet the SO_4, and journeys the greater part of the distance between them; Cl also travels to meet the Ba. Call the true velocities of these four ions, h, s, c, b, respectively: then the position of the precipitate of the meeting Ba and SO_4 may be thought to really measure, not $b : s$, but

$$\frac{b}{c} : \frac{s}{h}.$$

Now, on Kohlrausch's calculation, $h = 29$, $b = 3{\cdot}3$, $c = 5{\cdot}3$, s is not certain, but from Hittorf we may take it as roughly equal to the velocity of K, viz., 5·1; in which case

$$\frac{b\,h}{c\,s} = \frac{3{\cdot}3 \times 29}{5{\cdot}3 \times 5{\cdot}1} = 3{\cdot}5.$$

I by no means press this probably accidental agreement; and the true meaning of any results obtained by such methods as I have described I leave for the present open.

On my cursorily mentioning these very preliminary results in a circular to the committee on Electrolysis, Prof. S. P. Thompson suggested using a jelly, and we at once tried it. One cannot use any strong acid with gelatine, for it seems to spoil it, but acetic acid serves; and the siphon tube was accordingly filled with an acetic acid gelatine jelly, which went stiff when cold. Agar Agar jelly can be used with stronger acids.

The use of jelly makes the experiment much less troublesome, because there is now no difficulty in the manipulation, no special need for adjustment of the solution densities, nor danger from changes of level.

One objection to it is that, supposing the ionic velocities were determined in jelly, they could not easily be compared with Kohlrausch's numbers, which apply to weak aqueous solutions. There is of course no difficulty in determining the conductivity of the jelly or the slope of potential, as required in formula (1); but it is difficult to assign a value to K. The hypothesis that the solvent does none of the conduction, even though it be true for water, can hardly be pressed to include the case of a jelly of unknown and complicated constitution; especially as we found that the conductivity of plain jelly was actually considerably greater than that of dilute acetic acid.

The endosmose difficulty is not got over by the use of jelly—in fact, it may perhaps be accentuated; and another and unexpected difficulty presents itself. The jelly swells under the action of the current and exudes from the tube; but always in one direction only, viz., against the current. A cylinder of jelly an inch or two in length was ultimately protruded from the anode end of the tube; and cracks appeared in the substance of the jelly of a curious serpentine form which underwent noteworthy metamorphoses.

The position of the precipitate in these jelly tubes was not far from the middle of the tube, indicating that Ba and SO_4 travelled at nearly equal rates.

Second Series of Experiments.

I next proceeded to another form of the experiment, where a detecting substance was placed in the tube so as to be able to follow the motion of the ions along their journey, instead of only noting their time and place of meeting.

Various detectors were tried, but a simple and obvious one, able to show both anion and cation, is sulphate of silver.

A jelly tube containing, besides acetic acid, a solution of sulphate of silver, was arranged to join two vessels, each full of baric chloride solution. When the current passes, the barium travels with it and causes a precipitate of $BaSO_4$, which may be watched creeping on from point to point; the Cl at the same time travels against the current and causes a precipitate of Ag Cl, which may be likewise watched. The poor solubility of Ag_2SO_4 is of no consequence, because it is only wanted to *detect* the ions, not to absorb them and stop their motion; hence, however soluble a detector was used, the amount of it put into the tube ought to be almost infinitesimal, or it will cause disturbance and prevent the full velocity of the ion being observed.

There is some slight difficulty with a solid precipitate when free liquid instead of jelly is employed, for its settling causes currents and convulsive disturbances—especially in the vertical endsof the tube. Fluid detectors, whose colour the ions change, are therefore in some respects better.

Roughly examining the results obtained by the methods just described, one may say that they give the velocity of Ba through jelly, for a fall of one volt per centimetre, as about ·00012 centimetre per second; the velocity of Sr is about ·00015. The speeds of Cl, Br, and I are not very different from each other, and about ·00024. This rough statement is merely to give a notion of the order of magnitude of the velocities obtained, and by no means represents the full deduction from the tabulated numbers.

Experiments on Speed of Hydrogen and Hydroxyl.

To detect the motion of *Hydrogen*, Mr. Robinson devised the following arrangement:—We happened to have been using phenol-phthallein as a detector of alkali in some other quite distinct experiment, and so it was a handy substance. The jelly tube contains a little phenol-phthallein and a trace of common salt, just made alkaline enough with soda to bring out the colour. The solution in anode vessel is H_2SO_4; in cathode vessel the same, or sometimes $CuSO_4$.

The result is that SO_4 travels one way, and H_2 the other. As the H travels it liberates HCl, and decolorises the solution. As the SO_4 travels it also decolorises the solution by forming neutral Na_2SO_4. The velocity of hydrogen, for 40 volts applied to a 40 centimetre tube, came out from the very first observation thus made

·0029

centimetre per second. Kohlrausch's theoretical number, deduced from conductivity and migration data, is

·003

Later experiments gave respectively ·0026 and ·0024. SO_4 seems to travel at about one-third this speed.

Another experiment can be made with NaHO in cathode vessel, and $CuSO_4$ in anode; and then with NaCl and phenol-phthallein in the tube, as before, but colourless. HO now travels against the current and produces colour as it goes. It seems to travel nearly as quickly as hydrogen.

(To be continued.)

AUTOMATIC CALL BELLS.

MR. HENRY BOARDMAN, Northfield Place, Bradford, has just patented a very complete and trustworthy method of ringing morning call bells automatically, by electricity, which is likely to be largely used, not only in hotels and public institutions, but also in private houses where the noisy and somewhat uncertain services of night-policemen are required. By Mr. Boardman's system it is possible to ring bells in any number of bedrooms from a central clock at any hour of the morning. In the lobby of his house he has hung an ordinary Austrian clock, inside the lower part of which a switch of the Umschalter pattern is fixed, and under the face of the clock there is a semi-circle of brass studs representing every quarter of an hour from three o'clock in the morning until nine. Each stud is connected to a separate upright bar of the switch. A metallic lever attached to the hour hand of the clock passes over a row of teeth at its centre, and strikes one of the studs exactly at the quarter hours, remaining in contact for about five minutes, and then raising itself on the next tooth until it falls again upon the succeeding stud. This is found to be more sure in its action than is a trailing contact. The upright bars of the switch are marked with the quarter hours which they represent, and the cross bars are connected to the bed rooms, being numbered accordingly. One battery lead goes to the bed rooms and the other is connected to the lever under the clock dial. So long as no pegs are in the switch, all the circuits remain incomplete, but if, for example, the occupant of No. 6 placed his peg in the 8 o'clock upright bar before retiring to rest, the circuit will be completed when the lever touches that stud in the morning, and his bell will continue to ring for the time stated, or until he breaks the circuit by a switch provided for the purpose. The inventor has had the arrangement in use for more than twelve months in connection with the rooms of his own and a neighbour's house, during which time it has never failed.

LORD WOLSELEY ON TELEGRAPHY IN THE FIELD.

AT the United Service Institution last Friday papers on "Tactics as Affected by Field Telegraphy," were read by Colonel Lonsdale A. Hale, R.E., and Major C. F. Beresford, R.E. Lord Wolseley presided, and among those present were Lord Chelmsford, General Erskine, C.B., General Sir Beauchamp Walker, General Sir Gerald Graham, Admiral Sir E. Fanshawe, Admiral Sir Erasmus Ommanney, Major-General Webber, Colonel Moncrieff, and Colonel Routledge.

In the course of his remarks, Colonel LONSDALE HALE said it was an accepted fact that the successful conduct of the operations of strategy was greatly facilitated, and in some cases, only rendered possible, by the existence of telegraphic communication between the supreme strategical leader and his subordinates, and some little time ago it occurred independently to some of his brother officers immediately connected with the telegraphic work of the corps and to himself that if, in the operation of tactics the same kind of communication existed, similar advantages would be gained, and the leading rendered more effective. Colonel Hale afterwards reviewed the operations of the German army in 1870-1, and pointed out how circumstances would have been changed if army corps had been in telegraphic communication.

Major BERESFORD described the system by which outpost telegraphs might be used for obtaining information and for the transmission of orders. He sketched the details of the work, and exhibited the combined "telephone and sounder" invented by Captain Cardew. He also presented a regimental organisation for telegraph operations.

The discussion was opened by General Sir GERALD GRAHAM, who said he regarded the telegraph in the field as the mouth, ears, and eyes of an army. The telegraph gave the general the power of control, which had fallen away somewhat from the commander of a modern army. So far from being a dangerous aid to undue interference, it would give the commander the power to deal with circumstances with knowledge, and thus avoid the dangers which arose in the battle of Worth. As an instance of nerve displayed in warlike operations he called attention to the fact that telegrams were sent to the *Times* from the zariba around which a battle was raging.

Major-General WEBBER, Colonel JELF, R.E., and General Sir B. WALKER having spoken,

Lord WOLSELEY, in closing the discussion, said that most students of war present would agree with him when he said that telegraphy had a great tactical future before it, and he would go so far as to say that the nation which first adopted telegraphy in the field of operations, and the general who could have the service would have the best chances. It had been most interesting to him to hear the remarks which had been made as to the necessity of immediately adopting into the British army a system which would give our forces so great an additional power. The answer he had to give as to why such palpable and necessary improvements were not at once adopted was a very simple one. He was a believer in novelties, and he believed that the more we adopted novelties the better would be our army, and the better, therefore, it would be for the nation. Napoleon had a rule that a leader must constantly change his tactics, and the nation which most readily adopted novelties would have the most effective army. But this view was not much appreciated outside the circle of those who had to deal with the entire life of the army. If the army authorities asked for requisites for the army they were told that they must "economise" in some way to get them. There had been an earnest endeavour made on the part of the army authorities, as all connected with the army knew, to organise a force which might, from necessity, have to be sent abroad—two Army Corps and one cavalry division. So far as the men were concerned, he was justified in saying that they could be got ready to be put on board the ships before the ships could be got ready, and the nation could thus be defended from an enemy by striking that enemy elsewhere. But it was of no use talking of the necessity of providing novelties like telegraphs when the army had not even stores or transports. Most important as it was to have such things as telegraphs, the army felt it was of no use asking for them when it was thus deficient in the first means of moving. He cordially agreed with all that had been said as to the importance of having telegraphs for the army, and he would ask the meeting to thank the lecturers and all who had taken part in the discussion.

RESISTANCE PROBLEMS.

IN a communication to the *Electrical World* under the heading of "Another Problem in Resistance," Mr. Carl Hering writes thus:—

"The following problem, which occasionally occurs in practice, may be of interest to some of your readers. Two cells having different E.M.F's. are connected in multiple arc and discharge through a common resistance. When this resistance is infinitely great, the cell having the higher E.M.F. will evidently reverse the current in the weaker cell and discharge through it. When this resistance is zero both cells will discharge through it; hence there must be some value for the external resistance for which the current in the weaker cell is zero although it is connected to the circuit while the other cell is discharging.

"The problem is to find the value of this resistance, and also the current which will flow in the external circuit as well as in each cell in a common short circuit; also the current circulating through the cells when the external circuit is infinite, that is, open.

"The most frequent occurrence of this problem is in an ordinary armature in which the two parts are in multiple arc, but have not always the same electromotive force, as, for instance, when the field is unbalanced.

"Let E and E′ be the two E.M.F's., R and R′ the internal resistances, and C and C′ the two currents in the two cells, respectively. Let the external resistance be W and the current in the external circuit A. The resistances of all the connecting wires are supposed to be zero."

It is perhaps almost unnecessary to point out that the conditions in this problem are precisely the same as those met with in Poggendorf's well-known electromotive force test, and that no current flows through the circuit in which the smaller electromotive focre is situated when the equation $\frac{E}{E'} = \frac{W + R}{W}$, is satisfied, E_1 being the weaker of the two electromotive forces. The current flowing in W is of course $\frac{E}{W + R'}$. When the cells are in a common short circuit then the currents in each circuit will be $\frac{E}{R}$ and $\frac{E'}{R'}$ respectively; and when W is infinite, then obviously the current will be $\frac{E - E_1}{R + R_1}$.

Electrical Progress in Vera Cruz.—According to a correspondent, there is no lack of enterprise in the Mexican city of Vera Cruz. Commerce is flourishing on all hands, and the electric light is extensively used in many of the principal thoroughfares, both for public and private purposes. Telephonic communication has also been established, and in mercantile circles is highly appreciated.

THE ABDANK-DEPREZ MAGNETO BELL SYSTEM.

VERY little description is necessary to render the working of the Abdank-Deprez apparatus apparent to the veriest tyro in electrical pursuits. The transmitter is merely an electro-magnet attached to the end of a stiff blade spring and made to vibrate between the poles of permanent magnets, thus setting up a series of alternating currents so long as the motion continues.

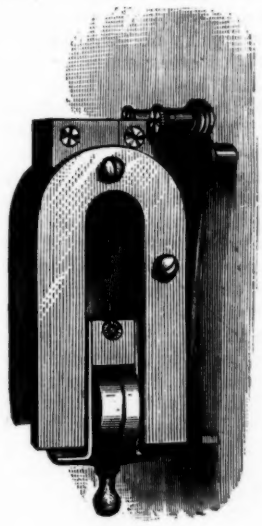


FIG. 1.

Two forms are shown in figs. 1 and 3, the first of which is set in action by pulling the handle under the armature and then letting it free, and the other is actuated by a push button arrangement. The bell

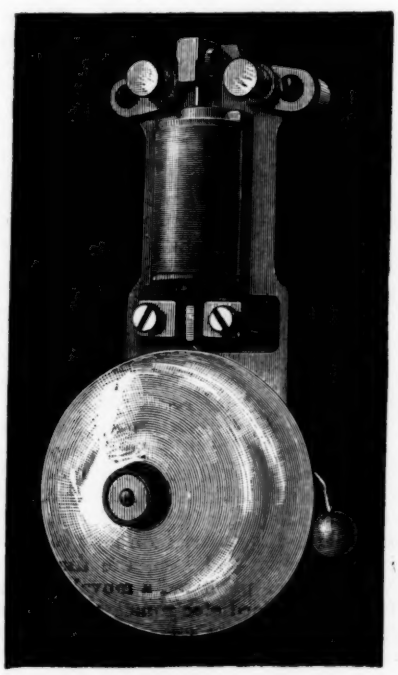


FIG. 2.

mechanism consists of a coil through which passes the armature, at the end of which is attached the hammer. The armature vibrates between the poles of a magnet in accord with the currents sent over the line; in fact, the arrangement is very much like that of a polarised relay. Figs. 2 and 4 represent two types of bell, one with the magnet above the dome, the other behind.

We understand that larger and more powerful forms of the apparatus have been in operation for several months in signalling over a distance of 600 miles. The various uses to which these instruments may be put were stated in our issue of May 6th, but, although efforts are still being made to bring this simple and inexpensive bell system into the market, we do not hear that any great degree of success has rewarded the

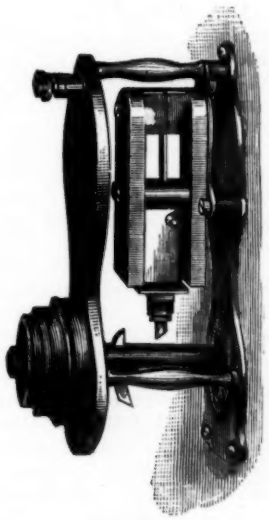


FIG. 3.

promotors. We hope, however, to learn shortly that a company has been formed on good business principles to bring the apparatus before the public, for we feel convinced that, if judiciously managed, the manufacture and sale of the Abdank-Deprez magnetic bells and pushes would form a profitable undertaking. In the same number of the REVIEW to which we have just referred, we took the opportunity of pointing out some defects to which the magneto-bell system has hitherto been subject, and a perusal of Mr. Swinburne's paper

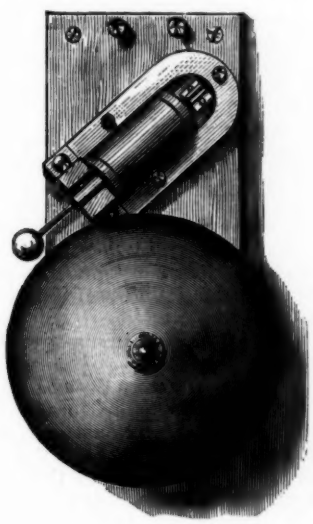


FIG. 4.

"On practical electrical measurement," on p. 492, will still further show how careful must be our manufacture of so-called permanent magnets. With due attention to technical details however, we can see nothing in the apparatus to get out of order for a very long time, if at all, and we think that users of electric bells would infinitely prefer the magnetic as exemplified in this, the most simple and recent form, to the voltaic, which is a constant source of trouble in the majority of instances.

ON A DOUBLE CHAIN OF ELECTRICAL MEASURING INSTRUMENTS TO MEASURE CURRENTS FROM THE MILLIONTH OF A MILLIAMPERE TO A THOUSAND AMPERES, AND TO MEASURE POTENTIALS UP TO FORTY THOUSAND VOLTS.*

By Sir WILLIAM THOMSON, F.R.S.

A FUNDAMENTAL requisite of a measuring instrument is that its application to make a measurement shall not alter the magnitude of the thing measured. When this condition is not fulfilled (as is essentially the case with an electric measuring instrument not kept permanently in or on the electric circuit or system to which it is applied) it is the magnitude as influenced or modified by the measuring instrument which is actually measured, and the measurement is to be interpreted on this understanding whatever may be the circumstances. Suppose, for example, the thing to be measured is the diameter of a fine wire, or of the carbon filament for an Edison-Swan lamp, or of a hair, or of a silk fibre. If the measurement is made by a microscope with the proper optical apparatus for measurement, the thing measured is absolutely unaltered by the measuring appliance. But if the measurement is made by an ordinary screw gauge, or by any other mechanical fitting appliance, however gentle, it is impossible to avoid some diminution of the diameter to be measured by the pressure of the measuring appliance, which introduces some slight uncertainty even in the measurement of steel or copper wire and very considerable uncertainty when a filament of softer material is to be measured.

The nearest approach in electric measuring instruments to the fulfilment of this condition, of not altering the magnitude of the thing measured, is attained by the electrometer when applied to measure difference of potential between different points of a wire or metallic mass of any shape in which electricity is kept flowing by a battery or dynamo or other electromotive apparatus. The insulation of any practical electrometer is so nearly perfect that the conduction of electricity through the instrument does not sensibly diminish the difference of potentials of the points touched by the electrodes. In this respect, therefore, the electrometer would be ideally perfect; but, alas, it is only for potentials of more than 400 or 500 volts that the electrometer in any shape has been made a convenient and fairly accurate standard measuring instrument for ordinary practical use. For less than 400 volts the practical solution in connection with electric lighting is afforded by a current-measuring instrument with a known resistance in its circuit; though for many differential measurements, and particularly for measurements of the insulation of submarine cables, and determinations of the insulating quality of insulators for many practical purposes the quadrant electrometer is found useful as a differential measuring instrument.

The quadrant electrometer in its most sensitive adjustment indicates about $\frac{1}{1000}$ of a volt, and with modified adjustments (heerostatic and idiostatic) can be used for measuring up to 300 or 400 volts. It is described in detail in the "Report on Electrometers and Electrostatic Measurements" in the British Association Volume for 1867 (Report of the Committee on Electrical Standards), and reprinted as Article XX. of my "Collected Papers on Electrostatics and Magnetism," so I need say nothing more of it at present. The electrostatic voltmeter exhibited and shown in action this evening, and represented in the annexed drawing, is an idiostatic standard instrument for measurement from 400 volts to 10,000 volts.

It consists of an air condenser with one of its plates capable of a to-and-fro motion, so as to vary the capacity of the condenser.

The fixed brass plates are supported so as to be accurately parallel to each other and in metallic connection, while they are thoroughly insulated from the case of the instrument. The movable plate is of aluminium, and is supported in a vertical position on a knife edge; the plane of its motion being parallel to the fixed plates and situated midway between them. The upper end of this movable plate has a fine prolongation which serves as a pointer for indicating the deflections on the scale of the instrument, and at its lower end is fixed a knife edge having its length perpendicular to the plane in which the plate moves.

There are two pairs of terminals, one pair for the fixed plates and the other pair for the movable plate, and each terminal is insulated from the case of the instrument. Of the pair on the left-hand side of the case, the terminal towards the back of the instrument is in metallic connection with the fixed brass plates, while that towards the front (which may be called the working terminal) is simply an insulated brass pin. A glass U-tube is suspended between these two terminals, and contains a safety arc of finest copper wire connecting them. The terminal toward the back of the instrument on the right-hand side is in metallic connection, through the V-groove support, with the movable plate; in other respects the pair of terminals on the right is similar to the pair on the left.

In order to save time in taking readings an arrangement is provided for checking the oscillations of the movable plate, and stops are placed to limit its range and prevent damage to the pointer.

When the fixed and movable plates are connected respectively to two points of an electric circuit, between which there exists a difference of potential, the movable plate tends to move so as to augment the electrostatic capacity of the instrument, and the magnitude of the force concerned in any case is proportional to the square of the difference of potential by which it is produced. In the use of the instrument this force of attraction is balanced by the horizontal component of a weight of any convenient amount hung on the knife edge at the bottom of the movable plate.

The scale is graduated from 0 to 60, and the divisions represent equal differences of potential—the actual magnitude of the difference per division being dependent upon the weight in use at the time. A set of three weights is sent with each instrument, of respectively 32·5, 97·5, and 390 milligrammes, providing for three grades of measurement in the proportion of 1 : 2 : 4. Thus the instrument shows one division per 50 volts with the link (the lightest weight) alone on; one division per 100 volts with the medium weight hanging on the link, and one division per 200 volts with all three weights on.

At from 8,000 to 10,000 volts there is some liability of a spark passing between the movable plate and one or other of the four fixed quadrant plates between which it moves; and 10,000 volts is about the highest potential for which the instrument can be used. For higher potentials my long range electrometer ("Collected Papers on Electrostatics and Magnetism," sec. 383, 384) is, so far as I know, the only standard electrometer which has hitherto been practically used. But with the experience I have had of gravity instruments for electric balances in general, and particularly of the electrostatic voltmeter, I am now convinced that an electric balance for weighing the direct attractive force between a fixed plate and a movable disc will be the best form of standard electrometer for all potentials exceeding 8,000 or 10,000 volts. I hope before the close of next session to be able to show to the Philosophical Society a convenient instrument of this kind, adapted to measure from 10,000 to 40,000 volts, and, possibly, even to 70,000 or 80,000 volts; although I cannot anticipate for measurement of such high electric potentials any great practical demand as far as the future of electric technology can be conjectured at present.

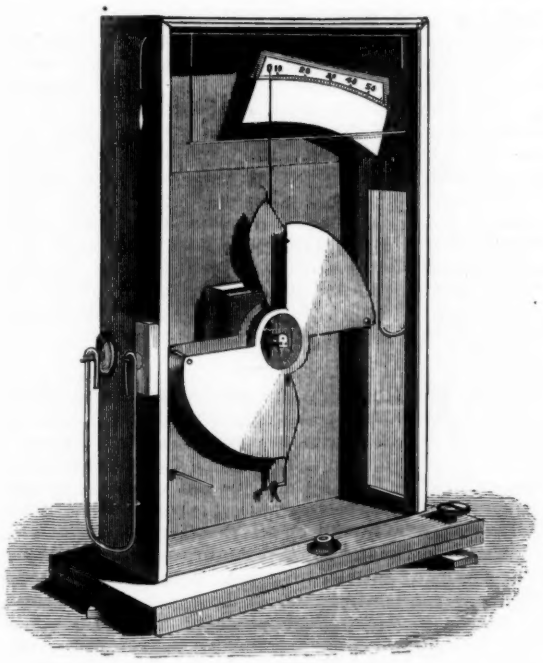
The electrometer is available with equal convenience for the measurement of electric potentials in circuits of direct current or of alternate current. In the latter

* Read before the Philosophical Society of Glasgow, April 20th, 1887.

application the result is quite definitely the square root of the time average value of the square of the difference of potentials between the point touched by its electrodes. A good deal is now being done for electric lighting and the electric transmission of power by means of circuits at high potentials of from 700 to 2,000 and 3,000 volts; and for such purposes the electrostatic voltmeter, described and illustrated above, is conveniently available. The method of finding potentials by measurement of current through a known resistance is also available, even for these very high potentials, but the electrometer is preferable because of the cumberousness and expensiveness of the resistance coils required by the current measuring method when the potential is more than 600 or 700 volts.

For potentials of from 500 volts downwards the method of measuring current through resistance is thoroughly convenient and practical. Thus we are led to the consideration of the current measuring branch of our "Two-branch" chain of measuring instruments.

Beginning with the feeblest currents, I may refer to the astatic mirror galvanometer of the form introduced by me about twenty-eight years ago, and now much used for laboratory and telegraph testing. This instrument is capable of being adjusted to measure currents



as low as the fifty-millionth of a milliampère with a coil of from 5,000 to 10,000 ohms. It has, besides, the great advantage that its sensibility can be easily varied through a wide range. Thus an instrument which, when in its most sensitive state, will measure the fifty-millionth of a milliampère can be easily arranged to measure the thousandth of a milliampère. Prof. S. P. Langley, of the Allegheny Observatory, U.S., recently used in his radiation experiments one of these instruments, which he had specially made and which included several important improvements of his own, such as the use of a very long suspending fibre and a very perfect mirror; he finds an instrument having a resistance of only twenty ohms capable of being used with perfect accuracy for the measurement of the two-millionth of a milliampère. In ordinary telegraph testing these galvanometers are commonly adjusted to measure currents down to about the millionth of a milliampère, and for special tests, as for instance, the measurement of the insulation of short lengths of core for submarine cable, sensibilities as high as those specified above are often used.

The current-measuring instrument commonly called by the name of galvanometer, whether it be the sine galvanometer, the tangent galvanometer, or any of the different varieties of mirror galvanometers in use, is essentially magnetostatic. That is to say, it is an instrument in which a controlling magnet is used to balance the electro-magnetic force produced on a magnetised steel needle by a conductor or coil through which flows the current to be measured. In the sine galvanometer and tangent galvanometer as originally used, and as still largely used for many important electrical measurements, the controlling magnet is the earth; but it is only in a locality far from dynamos and from wires carrying continuous* currents for electric lighting, that the terrestrial magnetic field suffices for a sine or a tangent galvanometer when any approach to accuracy is required; and thus in telegraph offices, workshops, and engine rooms, it is generally desirable, if not absolutely necessary, to use a much stronger magnetic field than that of the earth for controlling the needle of a galvanometer. But whether the controlling magnet be the earth or a steel magnet its force is essentially inconstant; and therefore a magnetostatic galvanometer of any kind requires some means for determining from time to time the coefficient by which the absolute value of the current measured can be calculated from its indications or a means of freshly adjusting the field to give any convenient absolute value to the readings on the scale of the instrument.

Sixteen or seventeen years ago I introduced a form of tangent galvanometer which came to be called the "paddle wheel galvanometer" from the appearance of the two coils being somewhat like the paddle-boxes of a paddle steamer. In this instrument two coils adjustable to any desired equal distances on the two sides of the centre act on a small needle or group of small needles hanging by a single silk fibre and carrying a pointer of about 8 centimetres length which shows deflections on a scale of unequal divisions proportional to the tangents of the deflections. Ordinarily the needle is acted upon by the terrestrial magnetic force alone, but sometimes in laboratory experiments a controlling magnet is placed either to augment or to diminish the controlling force on the needles. This instrument, though capable of considerable accuracy for absolute measurement in a locality free from local magnetic disturbance was replaced by my graded galvanometers† which have been found much more convenient for general purposes, and have been somewhat largely used since they were brought out five years ago. I have never, however, been satisfied with them, and I have been incessantly occupied in the attempt to produce an adjustable magnetostatic tangent galvanometer, which shall be both more convenient for ordinary use, and more susceptible of high accuracy for scientific investigation than the graded galvanometers. I am not able this evening to show more than a half finished attempt to realise this object, but I feel that I am now nearly touching it, and I hope at the commencement of next session to be able to place before you a working instrument of the magnetostatic class which shall be thoroughly convenient for showing the number of lamps alight at any time in an ordinary dwelling house, lighted by Edison-Swan lamps with direct current, and which shall also be available as a scientific measuring instrument to measure currents of from 1 to 60 ampères with a proportionate accuracy of one quarter per cent. in the best part of its scale.

I have also made great efforts during the last six years to produce satisfactory constant standard instruments for measuring electric currents, and I have from time to time placed before you results in which the object was to some degree realised, but, as I have always told you, not satisfactorily. This time last year I placed before you, and explained, instruments depending on Faraday's discovery of the tendency of a

* The neighbourhood of a conductor carrying an alternate current for electric lighting, however strong, would not disturb the terrrestrial magnetic field for a sine galvanometer or tangent galvanometer in its neighbourhood.

† Patent No. 5,668 of 1881 (26th December).

globe, or cube, or short bar of soft iron to move from places of weaker to places of stronger force in a magnetic field.* Two of these instruments which you saw, and which were then nearly completed, are again before you, now indicating the potential of the current by which we are lighted this evening. You see, when I increase the potential by reducing resistance, how the indicator shows, now an augmentation of 2½ per cent., which makes the lights considerably brighter; now, again, a diminution of 1 per cent., and again the previous potential and the lights as they were. Since you first saw them these two instruments have been incessantly at work on the electric light wires in my house and laboratory, and have done good work all this time. I may say, in passing, they have allowed me to use much higher incandescence without risk to the lamps than would have been practicable without a trustworthy potential indicator, and personal, if not automatic, attention to regulate the potential according to its indications.

Though, however, they have so far been practically useful to myself, I am not satisfied with the instruments because they involve the use of the soft iron, the rententiveness of which is always a serious trouble which I have only been able to keep within bounds, not completely to eliminate, by the use of the current reverser which you see in connection with one of the instruments before you. I have therefore returned to the original discovery by Ampère of the mutual force between movable and fixed portions of an electric circuit, first utilised by Weber in his "Electro-dynamometer," to obtain a constant standard instrument for measuring electric currents without any of the trouble and residual inaccuracy entailed by the use of soft iron. After many trials I have succeeded in improving an electro-dynamic balance, towards which I made a great many trials five years ago; and within the last three months I have succeeded in my laboratory in making accurate measurements of currents of from 20 milliampères to 200 ampères by means of four instruments on the general plan of the rudimentary centi-ampère balance before you, in which a single movable coil is repelled and attracted upwards by two fixed coils, one below it and the other above it, and the total of the electro-magnetic force is balanced by a weight hung on a knife edge attached to the balance.† At the commencement of next session I hope to show you some of these instruments in a state fit for practical work. In the meantime I can only thank you for the patience with which you have listened to me this evening, and for the kindness with which now, as on previous occasions, you have allowed me to bring half-done work before you, and to tell you of what I hoped to do but had not yet done in the way of producing practically useful instruments.

NOTES.

Electric Light at the New London and Brazilian Bank.—An installation of about 70 60-watt Edison-Swan incandescent lamps has been successfully working at the above bank since January last. The plant is of a very complete nature, and consists of a 4 H.P. improved type Otto gas engine, driving a 5-unit dynamo machine, and charging 32 23L E.P.S. accumulators. The circuits are controlled by means of a No. 1 E.P.S. switchboard, fitted with ammeter and voltmeter. The battery is placed in the same room as the engine and dynamo, but is enclosed in a cupboard having sliding doors. Each cell is placed on a wooden tray supported by four oil cups, thus ensuring perfect insulation of the battery. The installation was erected by the Electrical Power Storage Company, which we understand has many office and private house installations in hand at the present moment.

* Patent No. 11,106, 9th August, 1884.
† Patent No. 2,028, 21st April, 1883.

Electric Lighting of the Pinos Altos Bullion Mills.—At the meeting last Friday of the Pinos Altos Bullion Company it was mentioned that amongst other improvements at the mills of the company the introduction of electric light is in contemplation. Electrical plating works are also to be erected, for which one of the electric lighting dynamos will supply current.

Defective Lighting at Brighton.—Complaints are rife at Brighton with reference to the inadequate lighting of the east-end of the borough, and the attention of the Corporation Gas Committee has been particularly directed to the Marine Parade, where some improved mode of illumination is sadly needed. The committee, however, have decided that they are not in a position to recommend any outlay at present. On the matter being discussed at last week's meeting of the Council, a strong opinion was expressed by several of the members that some steps ought to be taken with the view of properly lighting the Marine Parade at night, and Councillor Smith suggested that the electric light should be made use of. Eventually an amendment, taking exception to the committee's recommendation, was adopted.

Lighting Lord Wolverton's House.—The Gülcher Electric Light and Power Company, Limited, has just completed the lighting of Lord Wolverton's town residence, 7, Stratton Street, Piccadilly. The installation, on account of the small space at the disposal of the contractors and the desirability of suppressing any noise that might arise from the machinery, was a difficult one to undertake, but it has been most successfully completed. The plant consists of a 2 H.P. Otto gas engine, a No. 1 Gülcher shunt-wound dynamo fitted with a turned and perfectly-balanced flyweel of 2 feet diameter, and 27 Elwell-Parker accumulators. In the dynamo and engine room a special switch-board is fixed, designed for this installation by Mr. Mountain. The lamps at present in position number 48.

Electric Lighting for Chelsea.—At a recent meeting of the Chelsea Vestry, Mr. Mossop, the chairman of the Electric Light Committee, moved that the recommendation of the committee that the offer of the Cadogan Electric Light Company, in which it agreed, in the event of the vestry granting permission for overhead wires, to be bound by all the clauses both of the Provisional Order and the Act confirming the same, as if the company were the actual holder of the said Order and confirming Act, be accepted.—Mr. Wright said that the vestry had objected to the Chelsea Electric Supply Company putting up overhead wires, and it therefore should object to this company doing so. It was an impossibility to say that the wires would not break with the snow. He moved that the vestry does not consent to overhead wires, and Mr. Gigner seconded the amendment.—Mr. Mossop said the Cadogan Company wished to place itself in the same position as the company that had an Order, and in that Order there was a clause which prevented overhead wires. He thought it was folly for two people to go to one district and compete when there were other parts of Chelsea that were open, but that had nothing to do with the vestry.—The amendment was put and lost, and the motion carried.—The committee recommended, with regard to the letter received from the Chelsea Electric Supply Company, that the vestry inform the company that it will assent to the Board of Trade using its powers under Section 70 of the Provisional Order to suspend the obligations of the company in all streets in Schedule A, save in the following:—Pont Street, Hans Place, Lennox Gardens, Lennox Garden Mews, Clabon Mews, Cadogan Square, Cadogan Street, Draycott Street, and Draycott Place, for such term of years as it sees fit.—Mr. Mossop moved the adoption of the report. This was to allow the company to reduce its area. Mr. Moon seconded the motion, which was agreed to.

Bull-Fighting by Electric Light.—The novelty of a bull-fight by electric light drew an immense crowd to the Colon Piza, in the City of Mexico, on April 29th. Among the spectators were President Diaz and several members of his Cabinet. The arena was brilliantly lighted by 10 electric lights and the gaudy uniforms of the matadores fairly blazed. Of five bulls everyone was desperate in the blazing light, and horses and fighters were rolled over and tossed in a terrible manner. The result of the fight was four horses killed, several torn and crippled, two matadores nearly killed, and several picadors disabled. The dazzling light, the *New York Tribune* says, seems to make the animals wild. This was the first time bull-fighting had been tried by electric light.

Electric Lighting in the Royal Navy.—Orders have been received at Portsmouth for H.M.S. *Hercules* to be detained there for another fortnight, in order that she may be supplied with the electric light. Two dynamos will be used in connection with the installation.

Cork and the Electric Light.—The Cork city engineer has just made the following report to the Standing Committee of the Corporation :—"In compliance with the instructions 'that the city engineer, with Mr. Bate, select sites between the north and south channels for 100 electric lamps, and that the engineer report what number of the present gas lamps might be dispensed with, &c.,' I beg to report that I have laid down on a small map of the city, the position of 90 electric lamps, which would be required to light that portion of the city between channels, and as far westward as the Dyke Parade, and find that in that area the number of gas lamps which would be displaced is 351. The cost of 90 electric lamps at £22 10s. each would amount annually to £2,025. Assuming that the present gas lighting is fairly satisfactory, the cost of 351 lamps (displaced by the electric lamps) at an average cost of £3 7s. 8d. each, would be annually £1,187 11s. The additional cost of the electric lamps would be, therefore, £837 9s. The Electric Light Company only propose to light the centre portion of the city, leaving the remainder to be lit by the gas company, who would probably increase the price both to the corporation and private consumers. Even if the proposed alteration showed a slight saving I would be slow to recommend its adoption in this very improving age, electric lighting being to a certain extent in its infancy. A newer and more improved method may at any moment be put forward, the pecuniary advantages of which would outvie the system now proposed. I recommend, therefore, that the consideration of the question be deferred for the present." The Mayor said he thought that was a very sensible report. At present the electric light, in his opinion, could only be used in places where gas was very expensive. Supposing they introduced the electric light into Cork, the gas company would increase their charges for the gas, and make their money all the same out of the private consumers. The proposal of Mr. Bate was, therefore, in accordance with the city engineer's suggestion, deferred for a time.

Electric Lighting in Dresden.—Dresden Town Hall has been experimenting for three quarters upon the electric light. Cost per incandescent lamp per hour—first quarter, 1·46d.; second quarter, 1·18d.; and third quarter, 0·82d. Its use is to be extended. The gas company undertakes the supply.

Electric Lighting from Niagara Falls.—The Buffalo Electric Light Company, we learn from a daily contemporary, has entered into a contract with the Niagara Falls Hydraulic Tunnel and Power Company to take 10,000 horse-power, at 15 dols. per horse-power per annum, for lighting the city and manufacturing purposes. The route for the proposed cable has been surveyed from Niagara Falls, a distance of 20 miles. Negotiations are also pending for lighting and supplying power to other towns in the vicinity.

Electric Lighting in Greenock.—From the proceedings of the Greenock Police Board last week, says the *Gas World*, we have conclusive evidence that the electric light in that town has not proved a success. The chances in its favour in Greenock were exceptional. Abundance of water, as a general rule, courses down the hill-side in a lade to supply motive power to the sugar mills, and upon this lade the turbine used to turn the dynamos was placed. The cost for motive power was therefore nominal. Whether the Roxburgh Street Refining Company was dissatisfied with the light, or whether it was not paying the authorities to supply it, we do not know, but the parties have been negotiating to have the contract terminated. The Electric Lighting Committee some time ago adopted a minute agreeing to give the company a rebate of 25 per cent. on the cost of the electric light for the past twenty months on condition that the contract should terminate on the 7th of May (now past), and that the company should use gas in the char house until September, 1888. This offer the company accepted, the electric light has been discontinued, the attendant discharged, and arrangements have been made for preserving the turbine and dynamos in good order.

(Perhaps Mr. Beckingsale can tell us the real facts of the case ?)

Train Lighting by Electricity.—The Brighton and South Coast Railway Company seems to be extending the Stroudley-Houghton system of electric lighting in the trains on its lines. A great improvement in the illumination of the carriages is noticeable and is frequently commented upon by passengers; but can anyone inform us of the cause of the periodic diminution of brilliancy which is observable when the trains are in motion? The lights are steady enough when the trains are stationary.

Telephone Wires and the Storm in the North.—The telephone communication between Liverpool and Manchester was interrupted during the recent storm owing to a large tree being blown across the wires between Wigan and Liverpool.

Telephone Wanted.—Tenders are invited for the construction of telephonic communication between the fire station at the Public Hall, Haslingden, and the Waterworks at Rawtenstall. Specifications may be seen and forms obtained on application to Mr. T. Woodcock, clerk to Local Board, Haslingden, to whom tenders must be sent before noon on 2nd June.

Female Telegraphists.—We learn that an important movement has been started amongst the female telegraphists employed by the Post Office. Its main purpose is to obtain an increase in the wages, and a reduction in the number of hours of work. There are 800 female and 1,500 male clerks at St. Martin's-le-Grand alone. A petition is to be presented to the Postmaster-General, recommending the formation in the female department, of a senior class, similar to that of the male staff; that the scale of pay shall be, for the lower class, from 12s. to 38s. a week; and for the senior class, from £100 to £115 a year; and requesting that the working day be limited to seven hours, and that the annual holiday be increased to three weeks after one year's service, and to one calendar month after twelve years.

Telegraph Wires in New Orleans.—The city of New Orleans is about to adopt the system of Colonel Flad for overhead wires. This consists, according to the *Scientific American*, in erecting tall towers at the street corners, which will carry the wires over the roofs. The system will be under the supervision of the Commissioner of Public Works, and the older method of running the wires, telegraphic, telephonic, and electric lighting, on poles will be abolished. The towers will be classified for the different classes of wire; and the wires are not to be less than 10 feet above the roofs. The Star Iron Tower Company, of Fort Wayne, has received an order for 224 towers.

Military Telegraphs.—The Royal Engineer Telegraph Battalion, with the greater portion of its equipment, arrived at Chobham Common on Monday afternoon from Aldershot, and encamped on one of the highest ridges, where it will remain several weeks.

Telegrams to the Continent viâ America.—In reply to Mr. Baden Powell in the House of Commons, Mr. Raikes said he had ascertained that the Commercial Cable Company had accepted from merchants in Liverpool messages for Bremen and Havre, and such had been paid for to America and from America to France. This practice was contrary to the agreement between the Department and the company, and was not followed by any other American Cable Company. The average time taken in transmission between Havre and Liverpool was under an hour, and therefore there must be some mistake in saying that there was a saving of from one and a-half to two hours in transmitting a message *viâ* New York. The whole question of telegraphic communication between England and the Continent was at present receiving his careful attention.

Submarine Telegraph Property.—*Engineering* last week contained an article upon this subject, in which the conclusions drawn from the financial position of the Globe Telegraph and Trust Company were that, taking submarine telegraphic enterprise as a whole, it does not yield an average return all round of 5 per cent. upon the capital which has been devoted to it, and that so long as this is the case it will be well to make the best of all existing undertakings rather than to launch cut into new competitive ventures.

Irish Cables.—Sir Edward W. Watkin, Bart., M.P., according to a contemporary, has offered to subscribe a sum of money towards the cost of laying a cable between Tory Island Lighthouse and the mainland of Donegal, on condition that nine other gentlemen are found willing to contribute each a similar amount.

Pendulum Experiments.—The famous experiments which Foucault made in the year 1851, at the Pantheon, are now being repeated on a larger scale by some physicists, at the tower known as Saint Jacques, in Paris. The pendulum employed consists of a steel wire 35 mils diam., nearly 130 feet long, and a copper sphere for bulb weighing a little over half a hundredweight. The excursions of the pendulum are marked on a zinc table 13 feet in diameter, and the line, traced by a gold pencil attached to the under side of the bulb, will be marked on sensitised paper by an electric current. The experiments will be continued for several months, and have for their object, says *Industries*, the revision of Foucault's experiments, the verification of the usual formulæ used in the theory of the pendulum, and the demonstration of the earth's daily rotation in the way originated by Foucault.

The Schuyler Electric Light System.—Visitors to the Schuyler factory at Hartford, U.S.A., are delighted, we hear, with the exhibition tests. A favourite experiment is to place in circuit one of the series incandescents of 25 C.P. and forty-five arc lights, and to suddenly switch off all the arc lights, leaving the one incandescent alone burning in the circuit, and the machine running at full speed. This one incandescent can be left in such a position for any length of time without injury to dynamo or lamp.

Press Messages.—The following will give some idea of the total number of words sent on one evening, on important political occasions, from the G.P.O. central station :—April 8th, 1886.—Mr. Gladstone's Home Rule Bill, 1,050,500 words. April 16th, 1886.—Land Purchase Bill, 841,500 words. June 7th, 1886.—Irish Government Bill (Division), 863,700 words. 1,050,500 words mean 525 columns, 87 pages, 11 sheets, 6 *Times*.

County of Middlesex Natural History and Science Society.—A *soirée* was held at the rooms of this society in Chandos Street on Monday evening, when, amongst numerous other objects of interest, several electrical instruments were displayed.

A Foolhardy Action.—John H. Simpson, in charge of the dynamos at 41, Trinity Place, New York, says the *Electrical Review* of that city, desired to show a friend how he could withstand the electric current : "Electricity doesn't affect me much any more," said Simpson ; "what would knock you out in a second I can hold without turning a muscle." Simpson explained about the two currents and the dynamo and started in. He took one wire first with one hand and then with both hands. There was no damage done apparently, and the foolhardy engineer then seized both wires, putting one hand on each. No sooner had he fairly touched them than the lights went suddenly out. Simpson's arms stretched out straight and stiff and he fell heavily to the floor. He died instantly.

Personal.—M. Leon Somzee, the well-known gas engineer and electrician of Brussels, has been made a Commander of the Legion of Honour.

Electricity in the Royal Navy. — Considerable doubts have been raised in naval circles regarding the real value of the Brennan torpedo, for the patent of which the Admiralty paid £110,000. It is stated that "my Lords" were led to believe that the weapon could be directed from shore at a distant object with almost unerring aim, whereas it is now apparent that the range is confined to one mile only, beyond which there can be no certainty that it will reach its mark.

Institution of Civil Engineers.—The president of the Institution and Miss Woods gave a conversazione on Wednesday evening at the South Kensington Museum, and there was a very numerous attendance. The company included Sir J. Ramsden, Sir I. L. Bell, Sir H. Thompson, Sir W. Thomson, Sir D. Adamson (president of the Iron and Steel Institute), Sir J. Coode, Sir J. Brunlees, Sir C. H. Gregory, Sir E. J. Reed, M.P., Admiral Fremantle, and Sir P. Cunliffe Owen. The string band of the Royal Artillery performed, and a party of vocalists, under the direction of Mr. E. Plater, contributed a selection of glees, madrigals, and part-songs in the lecture theatre, where also Mr. Corney Grain gave two entertaiments.

Primary Battery. — Messrs. Mark Bailey & Co. invite the electrical trade and users of primary batteries generally, to call and see their improved regulating battery, so that they will be able to judge for themselves as to the improvement and efficiency.

The Glasgow International Exhibition.—The official prospectus of the forthcoming exhibition at Glasgow has just been issued, and notice is given that applications for space must be sent in before 1st November. The site extends to 60 acres, and the buildings will cover about 10 acres. The exhibition will open in May, and remain open about six months. A special section, No. 11, is allotted to electricity.

Obituary.—We regret to announce the death at Kirkcaldy, on May 15th, of Mr. James Townsend, local manager to the National Telephone Company in the Scottish South-Central district. Mr. Townsend was an electrician, and more especially a telephonist, of great promise, and his early death is the source of infinite regret to all who knew him. He was assistant honorary secretary to the East of Scotland Naturalist Society, before which body he had read several papers dealing with electrical subjects ; and was elected associate S. of T. E. & E. only some six weeks ago.

The Late Mr. Fawcett.—A bronze statue of the late Mr. Henry Fawcett has been erected in his native city, Salisbury, and was unveiled by Lord Pembroke on Wednesday.

Electricity and Throat Affections.—The German Crown Prince is suffering from a swelling or growth in the larynx, and Dr. Morell Mackenzie has been summoned from London to attend him. The doctors are disagreed as to the necessity for an operation, but Dr. Morell Mackenzie is of opinion that by electricity, cauterisations, &c., a complete cure can be effected.

Insulated Conductors.—We are indebted to Mr. David Brooks, of Philadelphia, for a copy of his paper on the subject of conductor insulation, which was announced to be read at the meeting of the New York Electrical Society on the 17th inst.

Specifications Issued.—The regeneration or production of chromic acid from exhausted battery and other solutions, D. G. FitzGerald, 21st April, 1886, No. 5,542; Improvements in switch boards for telegraphic and telephonic purposes, A. Browne, 5th May, 1886, No. 6,107 (this is the specification to which we drew attention last week in a note "The Patent Office not Infallible"); Improvements in secondary batteries, C. Smith, 11th June, 1886, No. 7,848; Improvements in and connected with incandescent electric lamps, Rankin Kennedy and Robert Dick, 12th June, 1886, No. 7,919; Improvements in secondary batteries or accumulators, A. M. Clark, 22nd June, 1886, No. 8,226; Improvements in electric cables, S. F. Shelbourne, 23rd June, 1886, No 8,303; Improvements in regulators for electric arc lights, A. J. Boult, 12th August, 1886. No. 10,331; Improvements in the arrangements for electrically lighting railway trains, I. A. Timmis, 14th September, 1886, No. 11,686; Improvements in suspending overhead telegraph, telephone, and like lines, A. E. Harris, 29th December, 1886, No. 17,052; Improvements in or connected with transmitting gear for electric motors, specially adapted for use on electrically propelled vehicles, J. Y. Johnson, 22nd February, 1887, No. 2,765; Improvements in telephones, A. J. Boult, 16th March, 1887, No. 3960; Improvements in and connected wih the measuring of alternating or intermittent electromotive force, Robert Dick and Rankin Kennedy, 17th March, 1887, No. 4,027.

The Edison Incandescent Lamp Patent in Germany.—The board of the German Edison Company, we learn, calls attention in its annual report to the great difficulties against which it has had to contend, especially those created by the "unjustifiable imitations of the incandescent lamp patent." It is also stated that, although five judgments have been delivered in favour of the Edison Company, a definite decision has not yet been arrived at. It is complained that in the meantime the patent has run more than half its time, and the competition, against which thoroughly energetic steps cannot be taken, is continually increasing. The Edison Company has for years been carrying on fruitless negotiations with a view to liberating itself from the crippling influence of the French Compagnie Continentale. This state of affairs drew the Edison Company towards the firm of Siemens and Halske, and led to an extension of the contract already existing with that firm. The title of the Edison Company will henceforth be the Allgemeine Elektricitats Gesellschaft (Universal Electric Company.)

The Lundy Island Cable.—According to a financial contemporary, which publishes extracts from the Cable Company's last balance sheet, the concern does not appear to be so prosperous as could be desired. This is all the more disheartening considering the good and humane purpose for which the cable was laid. One item for a cable, which is only 13 miles in length, reads thus:—"Cable laid, and spare cable at Swansea, £4,750 15s." Another item reads:—"Land wires, £330." We believe the land line is not more than four or five miles long, therefore these sums appear to be tending somewhat to wasteful expenditure. During the year in which the cable was ruptured, the cost of repair was over £1,000, a sum which we do not hesitate to say was outrageous.

Legal.—*In re* the Electric Portable Battery and Gas Igniting Company.—Last Saturday, Mr. Justice Stirling, upon the petition of a creditor, made the usual order for the winding up of this company.

M. Gaulard's Nine Facts.—Perhaps M. Gaulard, when stating the "nine facts" which he innocently and fondly imagines entitle him to pose as the inventor of secondary generators, considered himself in possession of the field, and wished our readers to understand that "possession is nine points of the law."

Is Electricity Matter?—The article on this subject from Mr. Zacharias, was originally sent by him to our excellent contemporary *Industries*, with the request that if thought desirable it should be forwarded on to us.

Thomson-Houston International Electric Company.—On and after the 1st of June, all letters, papers, &c., should be addressed as follows:—Thomson-Houston International Electric Company, Michaelisbrücke, Hamburg, Germany. The telegraphic and cable address will be Cutout, Hamburg.

"The Countess."—We are desired to state that Mr. Elieson was in Spain at the time the electric boat, with which he is connected, and to which we referred in our notes last week, was launched.

College and Bench.—The following good story comes from America. A number of students visiting the Lytem central electric light station listened for some time in silence to a description by the electrician-in-charge of the beauties and merits of the system, when finally one of them, either to show off his knowledge or thirsting after a further supply of that commodity, enquired how many volts were employed? The electrician, with a condescending smile, remarked, "We don't use volts any more; they were condemned by our company six months ago."

Efficiency of Dynamos.—We noticed at the Manchester Exhibition a very pretty arrangement—by Mather and Platt—of compound vertical steam engines for driving the Edison-Hopkinson and Manchester dynamos. It would be interesting as well as instructive to know the efficiency of the combination, meaning thereby the percentage of I.H.P. actually obtained at the dynamo terminals. Both types of machine have been carefully tested by the Drs. Hopkinson, but under conditions which can scarcely be realised in actual practice, and we trust the opportunity now afforded for a test under ordinary installation conditions will not be lost.

Finsbury Technical College. — The second-year students in the electrical division visited the works of Messrs. Paterson & Cooper at Dalston, on Friday, accompanied by Prof. Thompson and the demonstrators, Messrs. Robertson and Cockburn. An opportunity was afforded of inspecting the dynamos, lamps, and instruments made by the firm in all stages of their construction.

Telegraphic Extension in Cornwall.—The inhabitants of Polperro, Cornwall, having recently forwarded to the Postmaster-General a largely and influentially-signed memorial, requesting the extension of the telegraph wires to that town, a reply has been received to the effect that as it has been estimated that the revenue from telegraph business would not pay the working expenses, he is precluded by the Treasury regulations from recommending an office to their lordships, except under guarantee.

Correction.—In our article on the Manchester Exhibition in the REVIEW for May 13th, page 448, at end, for "under the superintendence of Mr. J. Clark, the company's engineer, assisted by the electrician, Mr. Poole," read:—"The out-door work of erection of wires, &c., was carried out by the company's engineer, Mr. T. S. Clark, whilst the indoor work, consisting of the exchange and the electrical fitting up of the company's exhibit, was done by Mr. J. Poole, the company's electrician."

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Medical Electric Belt, Truss, and Health Appliance Company, Limited.—An agreement dated 26th March, between Messrs. T. Wood, R. H. Thomas, and L. E. Levy, cites that the two former are at present in employment of the Medical Battery Company, Limited, of 52, Oxford Street, the first as manufacturer of surgical appliances, and the second as consulting electrician. Mr. Wood is absolutely possessed of a business of manufacturing, and dealing in surgical trusses, belts, and bandages, carried on under style of E. Fava and Co., at 150, Great Portland Street. As consideration for the purchase of this business and for the services of Messrs. Wood and Thomas, who are appointed joint managers, the company will pay them such salary as may be agreed upon, and allot to each of them 50 fully paid shares. In the first instance 200 only of the company's shares will be issued, the remaining 3,700 shares to be held in reserve for future issue.

Oriental Telephone Company, Limited.—An extraordinary meeting of the shareholders in this company took place on the 20th ult. at the City Terminus Hotel, Cannon Street, when resolutions were passed authorising certain alterations in the Articles of Association of the company. The resolutions were confirmed at a meeting held at 14, Austin Friars on the 13th inst., and were duly registered on the 17th inst.

The annual return of the company made up to the 11th inst. was filed on the 17th inst. The nominal capital is £300,000 in £1 shares. 298,242 shares have been taken up, and upon 220,000 shares 11s. per share has been called up, the remaining 78,242 shares being considered fully paid. The calls paid amount to £120,896 10s. 3d. and unpaid to £103 9s. 9d.

Cadogan Electric Light Company, Limited.—The registered office of this company is 137, Regent Street, W.

Primary Battery Company, Limited.—The office of this company is removed to Palace Chambers, Bridge Street, Westminster.

NEW COMPANY REGISTERED.

Aluminium Syndicate, Limited.—Capital £30,000 in £10 shares. Objects: To manufacture aluminium in accordance with the invention referred to in the application for Letters Patent, No. 8,531, filed 29th June, 1886, made by Francis Ignatius Ricarde Seaver, being a communication from Dr. Edward Caspar Kleiner, of Zurich. Signatories (with one share each): *George Cawston, Hatton Court, E.C.; H. V. Higgins, 150, Sloane Street; C. A. Scott Murray, J.P., Marlow, Bucks; *F. I. R. Seaver, F.R.S., Conservative Club; A. H. Bourke, 10, Throgmorton Avenue; J. O. Maund, 294, Regent Street; *Charles Newton, 1, Davis Street, Berkeley Square. The first committee of management consists of the signatories denoted by an asterisk, and Messrs. Ludwig Mont, of Droitwich, and R. Nevill, of Grantham. Mr. Edward Kleiner is appointed first manager and electrical engineer, at an annual salary of £700. Registered 19th inst., by Gadsden and Treherne, 28, Bedford Row.

CITY NOTES, REPORTS, MEETINGS, &c.

The Consolidated Telephone Construction and Maintenance Company, Limited.

THE directors, in submitting to the shareholders the report and accounts of the operations of the company for the year ending the 31st March, 1887, state that the latter show a net profit of £8,957 4s. 4d., which, with the amount carried forward from last year, leaves a balance of £10,127 8s. 6d. for disposal.

Their report proceeds:—The directors propose to deal with this amount as follows, viz., to pay a further dividend of £2 10s. per cent., making, with the interim dividend paid in November last, 5 per cent for the year, writing off the sum of £558 for depreciation of plant and machinery and furniture, thus leaving a balance of £1,695 18s. 5d. to carry forward.

The amalgamation of our subsidiary company, the River Plate Telephone and Electric Light Company, with its opponent, the United Telephone Company of the River Plate, has become an accomplished fact. As a consequence of this amalgamation, the shares held by this company in the late River Plate Telephone Company have ceased to exist.

We have received £10,277 in cash, in payment of the debt owing to us by the late River Plate Telephone Company, also £1,250 as compromise for a contract which that company had failed to fulfil for the supply of telephones.

The cumulative 9 per cent. dividend, amounting to £1,838 17s. 10d. up to 31st January, 1886, has also been paid us, and an amount standing in our books at the sum of £9,256, has now been converted into £8,985, in shares in the United River Plate Telephone Company, Limited, at par, and £11,564 in cash has been received, which amount is now available for distribution. A further considerable amount has to be received in connection with the amalgamation.

Out of the amount of capital returned to the company under the above mentioned arrangements, the directors purpose to dispose of £11,242 10s. by returning 1s. per share from the issued capital of the company, thereby reducing the nominal value to 14s. They also propose out of the amounts received to write off from the goodwill and patents accounts, the sums shewn in the accompanying statement.

Your directors have done all in their power to extend the sale of our manufactures abroad, and with this in view they exhibited at the Exhibition of Telephones, held in Brussels in the early part of this year. It was admitted on all hands that the articles manufactured by this company took the first place, and the Board trust that good results will follow.

Every effort has been made to keep down the working expenses, and but for the exceptional causes of the Belgian law suit, and the action which Colonel Gouraud has brought against the company, the present year's charges would have been less by a considerable sum than last year. This action against your company has been postponed from time to time, and at his further request the trial has now been postponed till after the 1st June next. Colonel Gouraud has also thought fit to commence an action against your directors for the course they have pursued, with your sanction, in co-operating with the Edison Gower-Bell Telephone Company in the action to prosecute infringers of their patents in Belgium.

Thus far, in Belgium all has gone on favourably to this company, though every obstacle has been thrown in our way. It is impossible to foretell what the result will be, should the suit be decided in our joint favour. It may, however, be stated that the damages claimed involve a very considerable amount. Negotiations are also proceeding by which the business of the Edison Gower-Bell Telephone Company in Portugal will be considerably improved.

Your directors have now purchased the entire machinery of the American Telephone Company, which was in use in your factory, for the sum of £2,300, thus placing your establishment in a most perfect and independent position with regard to our manufacturing capability.

The business of the subsidiary companies, in which this company is so largely interested, continues to make satisfactory progress.

The Telephone Company of Austria at the end of March, 1886, had 1,373 subscribers, representing a gross annual rental of £9,258. At the end of March, 1887, there were 1,791 subscribers, with a gross income of £11,682. An increase of 418 subscribers and £2,424 on the annual rental.

The Edison Gower-Bell Telephone Company at the end of March, 1886, had in its two exchanges, Lisbon and Oporto, 1,105 subscribers, paying a gross annual rental of £6,800. At the end of March, 1877, there were 1,370 subscribers, paying a gross annual rental of £8,778. This shows an increase of 265 subscribers, and £1,978 rental during the year.

The increases in the exchanges, as compared with 1886, may therefore thus be stated.

Telephone Company of Austria ...	418 subscribers	£2,424 rental.
Edison Gower-Bell Telephone Co.	265 „	1,978 „
Total increase for the year ...	683	£4,402

It is with sincere regret that the board have to announce the death of one of their colleagues, Mr. John Taylor, whose services proved of great value to this company.

Major FitzGerald and Mr. R. E. Bateman having taken their seats at the board of the United River Plate Telephone Company, the retirement of these gentlemen from the Consolidated board became necessary as part of the arrangement of the amalgamation.

London Platino-Brazilian Telegraph Company, Limited.

THE ninth ordinary general meeting of this company was held at Winchester House, Old Broad Street, on Monday, under the presidency of Mr. John Pender.

The Chairman in moving the adoption of the report (which was printed in the REVIEW last week), said the negotiations to which he referred at the last meeting as going on between this company

and the Western and Brazilian Company had not advanced, but the position of this company had materially improved, and when negotiations were resumed, they would benefit by that fact. The report included a recommendation of the payment, tax free, of a dividend of 4s. per share, making with the interim dividend 3 per cent. for the year.

Mr. Francis seconded the motion.

The Chairman, replying to questions, said it would be unwise, while negotiations were pending, to mention the amount of their claim against the Western and Brazilian Company.

The motion was carried unanimously, after which the retiring director and auditor were re-elected, and the meeting terminated.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 20th were £3,269, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending May 20th amounted to £5,978.

NEW PATENTS—1887.

6917. "Electric transformers, induction coils, or inductional resistance coils." W. M. MORDEY, C. E. WEBBER. Dated May 11.

6927. "Compound for covering electric wires." H. W. MERRITT. Dated May 11. (*Complete.*)

6928. "Compound for covering electric wires." H. W. MERRITT. Dated May 11.

6933. "Laying electrical conductors; apparatus therefor." D. NICOLL. Dated May 11.

6943. "Magneto-electric machines used for firing explosive charges for mining, &c." M. SETTLE. Dated May 12.

6957. "Telephonic apparatus." C. L. W. FITZGERALD. Dated May 12. (*Complete.*)

6972. "Obtaining derived currents of variable intensity from a main electric current." J. C. MEWBURN. (Communicated by La Société Anonyme pour la Transmissione de la Force d' Electricité.) Dated May 12.

6987. "Electric arc lamps." A. SIEMENS. Dated May 12.

6988. "Conveying electricity to movable vehicles." R. LAURENCE. Dated May 12.

6993. "Signalling by electricity." H. H. SLATER, A. S. NEWMAN. Dated May 13.

7013. "Electro-plating rollers, &c." D. A. APPLETON, F. A. BINNEY. Dated May 13.

7021. "Electro-dynamic and dynamo-electric machines." G. SCARLETT. Dated May 13.

7030. "Forming plates with composition for electric batteries." C. MALTBY-NEWTON. Dated May 13.

7040. "Combined electrical and pneumatic transmission or communication." E. GUTHRIE. Dated May 13.

7042. "Electric arc lamps." F. G. CHAPMAN, F. M. DEARING. Dated May 13.

7059. "Electrical accumulators and primary batteries." R. W. PAUL. Dated May 14.

7078. "Electrical water level apparatus for indicating by direct reading the capacities and rise and fall of gas holders, water in reservoirs, &c." P. WILLIAMS, W. POWLES. Dated May 14.

7079. "Dynamo-electric machines." E. WILSON. Dated May 14.

7093. "Containing jars or cells of primary or secondary batteries." W. G. SPURGEON. Dated May 16.

7096. "Membranes for electro-magnetic telephone instruments." A. A. CAMPBELL-SWINTON. Dated May 16.

7184. "Electric arc lamps." W. MACKIE. Dated May 17.

7185. "Electro-propulsive motors and application thereof to wheeled vehicles or rolling stock." W. H. AKESTER. Dated May 17.

7188. "Covering insulated electrical conductors." J. TATHAM. Dated May 17. (*Complete.*)

7189. "Secondary batteries." W. H. AKESTER. Dated May 17.

7191. "Connecting electrical conductors." A. BINKOWSKI. Dated May 17.

7202. "Electric telegraphs." A. J. BOULT. (Communicated by J. F. McLaughlin.) Dated May 17. (*Complete.*)

7235. "Safety mechanism or cut-out in electrical apparatus." F. C. PHILLIPS, H. C. HARRISON. Dated May 18.

7241. "Covering or coating telegraphic and telephonic wires or insulating material." D. SPILL. Dated May 18.

7265. "Phonic reception of electrical signals." C. ADER. Dated May 18.

7313. "Telephonic controller." E. H. FURSE, IMPRESSA MINERARIA ITALIANA. Dated May 19.

7315. "Field magnets." S. S. BROMHEAD. (Communicated by G. Perdretti.) Dated May 19.

7317. "Reversible electric batteries." J. KYNOCH, W. HABGOOD. Dated May 19.

7336. "Arrangement of electric switch." A. SLATTER. Dated May 19.

7360. "Dynamo-electric machines." G. C. FRICKER. Dated May 20.

7378. "Electric indicators and bells." W. MOSELEY, J. LEWIS. Dated May 20.

7394. "Primary electric batteries." J. A. KINGDON. Dated May 20.

7396. "Galvanic elements." C. M. PIELSTICKER. (Communicated by F. C. G. Müller.) Dated May 20.

7426. "Preparing aluminium, aluminium bronze, and alloys of aluminium by electrolysis." A. C. HENDERSON. (Communicated by P. T. L. Héroult.) Dated May 21.

7431. "Electric clocks." A. J. BOULT. (Communicated by M. Engelhardt.) Dated May 21. (*Complete.*)

7436. "Switch." A. B. GILL. Dated May 21.

7506. "Electric batteries and lamps suitable for miner's use, &c." PORTABLE ELECTRIC LAMP AND POWER SYNDICATE COMPANY, D. URQUHART, B. NICHOLSON. Dated May 23.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1886.

4112. "Improvements in iron telegraph posts." W. E. PEDLEY. Dated March 24. 8d. Claim:—The production of tapering telegraph or other posts by cutting or dividing into tapering portions, old rails or rolled iron or steel beams or the like, of ordinary uniform section, substantially as described.

4118. "Improvements in incandescent electric lamps." C. SEEL. Dated March 24. 8d. Relates principally to the make and break arrangement of the electric current in incandescent electric lamps, and consists in the first place in arranging the lamp in such a manner, that by means of turning a knob mounted on the pipe or bracket containing the wires, the lamp may be partially rotated. The lamp is fitted into a rotating bush and is brought into partial rotation by means of an eccentrically fixed pin, with the said knob, whereby the break and make of the current is caused. The invention consists in the second place in providing the lamp with spring contact blades, which keep the lamp in constant contact with the stationary contact surface. The invention consists in the third place in forming the bush partially rotating with the lamp, with a ⊤ shaped slot for the purpose of receiving conjointly the lamp and the globe gallery in the double bayonet slots. The claims are four in number.

4280. "Improvements in electro-magnetic apparatus to be used for curative and remedial purposes." J. R. CHISLETT. Dated March 26. 8d. Claims:—1. In electro-magnetic apparatus of the nature referred to, providing the sliding core with a rack into which a toothed wheel is arranged to gear, substantially as and for the purposes described. 2. In electro-magnetic apparatus of the nature referred to, using a flat horse-shoe shaped electro-magnet and providing the pole to which the armature is attached with a buffer of India-rubber or other analogous elastic material, substantially as and for the purposes described. 3. In electro-magnetic apparatus of the nature referred to, in which that pole of the electric magnet to which the armature is attached is provided with an elastic buffer, arranging an adjustable screw so that it passes through a slot in the armature, through the said buffer and screws into the magnet, substantially as and for the purposes described.

4407. "Improvements in electric arc lamps." F. THORNTON. Dated March 29. 8d. Claims:—1. In electric arc lamps the combination of an upper carbon holder having rack teeth, an anchor or pallet engaging directly therewith, and a pendulum for controlling the motions of the anchor, substantially as and for the purpose described, with reference to the drawings. 2. In electric arc lamps the combination with a toothed rack on the upper carbon holder of an anchor or pallet engaging directly therewith and a pendulum carried on oscillating frame pivoted to the core of the solenoid, substantially as and for the purpose described, with reference to the drawings. 3. In electric arc lamps the combination with a single solenoid in the lamp circuit of two or more pairs of carbons operated from the one solenoid either all at one time or one after another, substantially as described with reference to the drawings. 4. The general construction, combination and arrangement of parts constituting the improvements in electric arc lamps, substantially as described and illustrated by the drawings. 5. The general construction combination and arrangement of parts constituting the improvements in electric arc lamps, substantially as described and illustrated by the drawings.

5258. "Improvements in the manufacture of tubular telegraph and telephone poles." W. BAYLISS and E. JONES. Dated April 15. 4d. Claims:—1. Soldering the rivetted joints of tubular telegraph and telephone poles as described, for the purpose set forth. 2. Soldering around the upper edges of the strengthening bands of tubular telegraph and telephone poles, and around the adjacent surfaces of the poles, after the bands have been fixed thereon, for the purpose set forth.

5606. "An electric switch." W. H. PREECE and J. W. WILLMOT. Dated April 22. 6d. Relates to the switch described in the No. of the REVIEW for December 3rd, 1886.

5979. "Improvements in incandescent electric lamps." B. J. B. MILLS. (Communicated from abroad by W. Holzer, of America.) Dated May 3. 8d. Claim:—In an incandescent electric lamp the use of a double-barrelled glass tube or two single tubes secured together for bringing the leading in wires into soldering proximity but insulating them from each other, substantially as described.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

(*Continued from page* 482.)

APPENDIX II.

NON ZERO USE OF THE SECOHMMETER.

I.—In what has preceded we have supposed that the Secohmmeter was turned at such a speed, and the resistance of the arms of the bridge so adjusted that the galvanometer needle was brought to the zero that it would stand at if no current whatever was passing through the galvanometer. But that is not necessary, for equation (13), page 480, may be written in the form

$$Q_1 = E\,\frac{(q\,r - p\,s)\left(T - \frac{B}{A}\right) - p\left(L + \frac{p+r}{p}M\right)}{A},$$

where p, q and r are any resistances in the arms of the bridge (fig. 7), p. 479, and s the resistance of the coil under test. Also

$$Q_2 = E\,\frac{(q\,r - p\,s)}{A}\cdot\frac{\lambda}{g},$$

therefore generally the current that will pass through the galvanometer when the secohmmeter is turning at n revolutions per second is

$$n\,(Q_1 + Q_2) = \frac{n\,E}{A}\left\{(q\,r - p\,s)\left(T + \frac{\lambda}{g} - \frac{B}{A}\right) - p\left(L + \frac{p+r}{p}\right)M\right\} \quad (19)$$

producing a deflection, d, say.

If the secohmmeter be stopped and steady currents employed, let balance be obtained by increasing s to $s + \sigma_1$, the values of p, q and r remaining as before, and let a deflection, d', be produced when σ_1 is changed to σ_2, so that d' is the deflection produced by a current

$$\frac{E\,p\,(\sigma_1 - \sigma_2)}{A}.$$

Hence, since $$q\,r - p\,s = p\,\sigma_1,$$

we obtain from (19)

$$\frac{d}{d'} = \frac{n\left\{\sigma_1\left(T + \frac{\lambda}{g} - \frac{B}{A}\right) - \left(L + \frac{p+r}{p}M\right)\right\}}{\sigma_1 - \sigma_2} \quad (20)$$

Let $$d = l\,d',$$

where l is the lead of the secohmmeter, then we have from (20)

$$L + \frac{p+r}{p}M = \frac{l}{n}\,\sigma_2 \text{ approximately.} \quad (21)$$

Now σ_2 may be regarded as the apparent increase of resistance of the coil produced by the self-induction on turning the secohmmeter at the rate of n revolutions per second when the zero used in measuring the resistance with steady currents is at a distance, d', from the true zero, and the zero used in obtaining balance with the sechommeter revolving is at a distance $l\,d'$, from the true zero. This leads us to the following *simplified* method of measuring L, the coefficient of self-induction, or $L + \frac{p+r}{p}M$, if there be also mutual induction, without its being necessary to *accurately* measure the true resistance of the coil at all:—

1. Let a *rough* approximation be made to the resistance of the coil using steady currents, and let the resistance of the coil appear to be s ohms when the spot of light is somewhere near zero, say at 130 divisions from the zero.

2. Let the secohmmeter rotate at n revolutions per second, and let the coil now have an apparent resistance of $s + \sigma$ ohms when the spot of light is brought, not to zero, but to $l \times 130$ divisions on the scale, then

$$L = \frac{\sigma}{n}$$

or

$$L + \frac{p+r}{p}M = \frac{\sigma}{n}$$

if there be also mutual induction.

II.—At the commencement of this paper it was mentioned that we originally measured the coefficient of self-induction not by altering the resistance in one or more of the arms in order to obtain balance, but by leaving the resistances in the arms unaltered, and observing the galvanometer deflection when the secohmmeter was rotated. Equation (19) at once gives the formula that we employed with that method of using the secohmmeter, for, if p, q and r be the resistances of the arms that will produce balance with s for steady currents, equation (19) becomes

$$n\,(Q_1 + Q_2) = -\frac{n\,E\,p}{A}\left(L + \frac{p+r}{p}M\right);$$

let this current, $n\,(Q_1 + Q_2)$ produce a deflection, d_1 Next let s be increased by a known resistance, s', and let the galvanometer deflection for steady currents in the arms be d_2, then this deflection is produced by a current

$$-\frac{E\,p\,s'}{A}$$

$$\therefore \frac{d_1}{d_2} = \frac{n}{s'}\left(L + \frac{p+r}{p}M\right)$$

or

$$L + \frac{p+r}{p}M = \frac{d_1}{d_2}\cdot\frac{s'}{n}$$

or

$$L = \frac{d_1}{d_2}\cdot\frac{s'}{n}$$

if there be no mutual induction, the formula originally employed for measuring L.

This comparative deflection method of using the secohmmeter has received a high testimonial for great sensibility from MM. P Ledeboer and G. Maneuvrier who, unaware of the fact that it was devised and used by us rather more than a year ago, have recently brought it to notice in France. The large amount of excellent work that M. Ledeboer has done on self and mutual induction makes him well competent to judge of the relative sensibility of methods of measuring the coefficients, therefore we feel sure that he and his colleague will be the first to recognise the great increase of sensibility of our *zero cumulative* method beyond even the large sensibility possessed by our *comparative deflection cumulative* method for measuring the coefficients of self and mutual induction.

USE OF SECOHMMETER WITHOUT SPEED INDICATOR.

III.—It is important to notice that *all* known zero galvanometric methods of comparing the coefficients of self or mutual induction with one another, or with the capacity of a condenser, can be increased *enormously* in sensibility by the use of the secohmmeter, and, since in such cases the speed of rotation need not be known, a very simple form of secohmmeter without speed indicator can be employed. The comparison of the coefficients of self or mutual induction with one another, or with the capacity of a condenser, is usually effected by tests that are completed during the growth or the dying away of a current, since it is only during the variation of a current that self or mutual induction, or the electrostatic capacity of a condenser, evidence themselves. The effect of an error in the balance only lasts for a very short time, and therefore is very small if the error be small, that is, the the tests are not sensitive. Resistances are compared with steady currents lasting for a considerable time, but before attempting to accurately measure an unknown resistance it is a common practice to give the bridge key a tap to see whether the balance is so far out that a deflection of the galvanometer is produced for a current lasting for a very short time. Such a preliminary test is intentionally very unsensitive, but its sensibility is equal to that of the ordinary tests made for comparing the coefficients of self and mutual induction. But by the use of the secohmmeter it is now possible not merely to measure the coefficients of self and mutual induction and the capacities of condensers *absolutely*, but in addition, to *secure the same high degree of sensibility with tests that have hitherto had to be completed during the growth or dying away of a current that it is customary to obtain in the use of the Wheatstone bridge for measuring resistances with steady currents.*

Physical Society, May 14th.

Prof. W. E. AYRTON, Vice-President, in the Chair.

Mr. T. Mather was elected a member of the society.

The following papers were read: "On a Modification of a Method of Maxwell's for Measuring the Coefficient of Self-Induction," by E. C. RIMINGTON.

The method referred to is given in Maxwell's "Electricity and Magnetism," §778, vol. 2, and is called: "Comparison of the electro-static capacity of a condenser with the electro-magnetic capacity of a coil." The apparatus used consists of a Wheatstone bridge, having the coil in one and the condenser as a shunt to the opposite arm. In order that no deflection may be produced, either for steady or unsteady currents, a troublesome double adjustment of the resistances is necessary, and to obviate this the modification was devised. It consists in placing the condenser as a shunt to only part of the arm, and this part can be varied by sliding contacts, without altering the whole resistance of the arm. An ordinary resistance balance for steady currents is first obtained, and the sliders are then adjusted until no deflection is produced on breaking the battery circuit. Under these circumstances, it is shown that $L = K\,r^2\,\frac{D}{B}$; where K is the capa-

city of the condenser, r the resistance between the sliders, and D and B the resistances of the arms on which the coil and condenser are placed. The conditions of maximum sensibility are investigated, and also those under which a telephone may replace the galvanometer; in the latter it is shown that the only possible solution is when $r = B$, *i.e.*, Maxwell's arrangement. The author believes his modification would be made much more sensitive by adopting the "cumulative" method used by Profs. Ayrton and Perry in their secohmmeter, and in his case neither the speed nor the "lead" need be known.

Mr. W. N. SHAW asked whether any serious difficulties were experienced with telephones, owing to electrostatic capacities of wires, &c., and

Mr. W. E. SUMPNER pointed out that the particular arrangement given in Maxwell is not always the most sensitive, as was shown in his remarks at the last meeting of the Society of Telegraph Engineers.

Mr. BOSANQUET thought the method a valuable one, and hoped many experiments would be made on coils whose coefficients were calculable, in order to find out the differences between calculated and observed results.

Prof. AYRTON referred to the recent paper by Prof. J. J. Thomson in the *Philosophical Transactions*, and pointed out that the formula there given for the capacity of a condenser in electromagnetic measure, is identical with that given in Maxwell, § 776, when the printer's error of interchanging a and a in the denominator for R_2 is corrected.

"On the production of sudden changes in the torsion of a wire by change of temperature," by R. H. M. BOSANQUET, M.A. A very fine drawn hard platinum wire, 4 or 5 feet long, was used as a suspension for a ballistic galvanometer, and exhibited peculiar phenomena. The steel needles were replaced by brass ones and the peculiarities investigated. When the room was warmed, the needles swung round nearly 70° for a few degrees rise of temperature, and remained in about the same position for further rises. If it was now cooled a few degrees (3° or 4° F.) they quickly returned to their initial position. The author has not found a complete explanation, but believes it to be due to unequal expansion, and loose contact amongst molecules, and has devised a simple mechanism to illustrate his meaning.

Remarks and suggestions were made by Prof. PERRY, Mr. LANT CARPENTER and the CHAIRMAN.

"On a Magnetic Potentiometer," by A. P. CHATTOCK, read by Prof. REINOLD. The "so-called" magnetic resistance between two points on a magnetic circuit may be expressed as the ratio of the difference of potential to the total induction passing from one to the other (provided there be no magnetomotive force between them). From the fact that the volume integral of induction through a wire helix of constant cross-section is proportional to the average difference of potential between its ends, it follows that any alteration in that difference of potential will give rise to an E.M.F. in the helix proportional to that alteration. Hence, if the wire be connected to a ballistic galvanometer, the combination may be called a magnetic potentiometer. A helix is formed by winding wire uniformly on a piece of solid India rubber or canvas gas tubing, of constant cross-section, using an even number of layers to avoid external inductive effects, and leaving a small space between the turns so as to allow the tube to bend without elongating. Experiments made to measure the difference of potential between the ends of a magnet gave satisfactory results. One end of the helix was held stationary at one end of the magnet, whilst the other was moved quickly to the other end of the magnet, and the resulting throw of the galvanometer observed. This was next done at two operations, and the sum of the two throws was very nearly equal to the first. The results can be reduced to absolute measure by passing the helix through a coil of n turns bringing its ends together, and starting or stopping a current, c, in the coil, the resulting throw of the galvanometer being noticed. The magnetomotive force used in this experiment is $4 \pi n c$.

An interesting discussion followed in which Prof. PERRY, Mr. SHAW, Prof. AYRTON and Mr. BOSANQUET took part, the latter mentioning a measurement of magnetic-potential made by himself some years ago.

In consequence of the absence of Prof. S. P. Thompson, his paper on Secondary Generators was postponed till next meeting.

CORRESPONDENCE.

Spiel's Patent Petroleum Engine.

We have been consulted by Messrs. A. Shirlaw & Co., of Birmingham, the sole licensees for the manufacture in England and the Colonies of the above engine, upon the paragraph about it in your paper of the 20th. They are much surprised that you should have given currency to the gross and libellous misstatement in *Money* of the 18th, that "only two engines have been sent out since it (the Spiel Company) started 12 months ago, and that both have proved useless on account, &c." So far from there being any truth in, or grounds for this assertion, the facts are, that over 50 of the engines have already been made and 45 sent out, of which 28 have been sold, and have given full and complete satisfaction to the purchasers (except in one instance only, and there the failure to satisfy has not been owing to defects or demerits in the engine) and that the others are under exhibition in different parts of England, and also in Glasgow, Belfast, and the Australian Colonies. Everywhere they are highly approved, and are attracting attention. We enclose a print showing some of the testimonials received by Messrs. Shirlaw.

The publication of such a misstatement as that by *Money*, is calculated to cause the licensees serious injury. We have written separately to the publisher of that periodical; and we have to request you to insert the full facts in your next issue, with a proper apology for the introduction of the libellous extract from *Money*.

Thursfield and Messiter.

Wednesbury, *May 21st*, 1887.

[We are pleased to hear that the number of Spiel engines made and sold is considerably larger than was stated by our contemporary *Money*, and insert willingly this contra-assertion of Messrs. Thursfield & Messiter.—EDS. ELEC. REV.]

Glow Lamp Litigation.

In reference to the note in your issue of the 20th, I remark that you have made a mistake, saying that the German-Edison Company has instituted an action against the De Khotinsky Electrical Company, in Rotterdam, manufacturers of De Khotinsky's glow lamps.

The affair is quite the reverse: the De Khotinsky Electrical Company in Rotterdam has instituted an action against German-Edison Company for menacing the De Khotinsky Electrical Company to stop their business in Germany.

This case will appear in the Berlin Law Courts the 20th June next.

Capt. A. De Khotinsky,
Director of the De Khotinsky Electrical Company, Rotterdam.

Rotterdam, *May 23rd*, 1887.

Automatic Screw Making Machinery.

As solicitors for the Standard Machine Screw Company, Limited, we have had our attention directed to an article (editorial) in your issue of May 20th, page 468-9, which apparently discloses a serious infringement of our clients' patents. The usual proceedings will be at once taken against Messrs. Davis and Timmins, Limited. But in the last sentence of that article you say that "Messrs. Davis and Timmins control the patents covering the automatic screw-cutting machinery for Great Britain and Ireland," thereby making yourself party to a statement which is not true, and which is seriously damaging to our clients. We therefore request your immediate insertion of this letter. It will also be a needful warning to those who do not desire to be defendants along with Messrs. Davis and Timmins, Limited.

Butler and Middlebrook.

Leeds, *May 21st*, 1887.

[The above letter needs but little comment from us. Anyone reading the article alluded to must perceive that the patents mentioned therein as controlled by Messrs. Davis and Timmins are those relating to the machines used by that company. With such questions as to whether the Standard Company infringes Messrs. Davis and Timmins's patents, or whether Messrs. Davis and Timmins infringe the Standard Company's patents, we have absolutely no knowledge, nor, so far, has it concerned us in the slightest. Messrs. Butler and Middle-

brook say in their letter *apparently* infringes, and it is therefore evident that the lawyers of the Standard Company have not yet any certain knowledge on the subject. We do not see where the damage comes in, but perhaps Messrs. B. and M. are uncertain also on this point.—EDS. ELEC. REV.]

Secondary Generators or Transformers.

The most extraordinary letter of Mr. Gaulard calls for a notice by me, as it contains some reference to statements which I have made, and which I am prepared to uphold as correct and substantial.

His reference to the International Congress of Electricians and the twaddle talked at their meetings is only amusing, but it has no bearing on the question of the claims set up by Mr. Gaulard as an inventor.

Mr. Gaulard is welcome to all the forms of secondary generators described in his specifications and claimed therein. I do not suppose anyone begrudges him the possession. If they are of great value as he says, I for one congratulate him and hope to see them adopted and applied to distribution purposes everywhere.

The methods of measurements employed by Dr. Hopkinson in obtaining 89 per cent. of efficiency for the generator used at the underground railway stations were open to some doubt as to their accuracy, but be that as it may, 89 per cent. was not a high efficiency even at that date, and I happen to know a good many electricians who were not astonished at that result; any common induction coil would quite equal in efficiency the secondary generators of the same date.

Even at the risk of showing my ignorance of transformers, I here repeat that no transformer yet invented can be successfully employed in a constant current circuit with a variable current in the secondary, and I challenge Prof. Forbes and Mr. Gaulard to refer to a single example of such a transformer.

The example given by Mr. Gaulard at Tivoli, near Rome, is absurd; the system in use there is similar in every detail to the prior patents described in my articles. One lamp to each transformer is no system at all for distribution purposes, and I maintain that even in this simple system no economical regulation is possible.

The Tours installation was not worked in parallel until after the publication of the methods by other inventors than Messrs. Gaulard and Gibbs.

I did not claim to be the inventor of the system, using a transformer to supply the main high tension currents to the line, and, for the same reasons, neither Messrs. Gaulard and Gibbs nor Mr. Ferranti, nor any inventor now in the field can claim the place, either; what I claim is the special arrangement for putting such a system into practical use, described in my specification.

The nine "facts" upon which Mr. Gaulard bases his claims to be the only first and true inventor of every detail and principle in use in the distribution of electrical energy by transformers, are the most extraordinary grounds yet advanced in support of claims to invention. I thought we had reached the height of absurdity in the evidence of scientific experts, patent agents, and patent bamboozlers in the telephone and electric lamp cases, but these nine "facts" are far more entertaining to the ordinary student of the history of inventions; the references to the patent offices are extremely amusing. He is not, evidently, aware that patent agents and patent offices have a lot of patent tricks of their own, and that their conduct does not count for much in a discussion regarding priority of inventions.

The decisions of exhibition juries and their awards are now valued by the public for what they are worth. Reference to such awards may be gratifying to the receivers, but the whole system of awarding diplomas, medals and reports is well known to be a complete *fiasco*. Even the exhibition authorities have admitted this by issuing paper medals instead of the sterling stuff; the medals are like the reports—a show; at any rate, exhibition reports are of no value as evidence in a dispute about priority of invention.

I cannot understand those portions of Mr. Gaulard's letter referring to strictly scientific points in connection with transformers, and therefore I do not pretend to criticise these statements of his regarding series working transformers and the conditions of success which he claims to have been first to call attention to.

Rankin Kennedy.

May 24th, 1887.

Ohm-Second Unit—Errata.

In first line, fourth paragraph, read "units" for "hints."

In second last line of third paragraph read "at *same* time absorbing only 500 watts of electrical energy."

In the proper meaning of the word resistance, the figures 2,000 volts and one ampère would mean 2,000 watts of energy absorbed.

Rankin Kennedy.

May 24th, 1887.

"A Wonderful Battery at South Kensington."

I was always under the impression that the Science and Art Department was established for the advancement and the propagation of knowledge, but, if what has just leaked out be true, they must be holding back some valuable information in the electrical branch, for I think, Mr. Editor, that you will agree with me when I express the opinion that a battery having a *minus resistance* is undoubtedly a very valuable one indeed. I must confess that in my very wildest flights of imagination I never dreamed of such an one, but Profs. Carey Foster and A. W. Rücker appear to have one at the South Kensington Institution, for in the examination paper given by them on the 11th inst. there is the following question (No. 30):—

"When a coil of wire is connected in circuit with a battery and a tangent galvanometer, the galvanometer shows a deflection of 45°. If the wire is replaced by resistances of 24 and 25 ohms in turn, the deflection is 46° in the first case and 44° in the second. Find the resistance of the wire. Tan. 44° = 0·966, tan. 45° = 1·000, tan. 46° = 1·036."

In other words, the question stands thus:—

Current through 24 ohms = 1·036
" " 25 " = ·966
" " x " = 1·000.

Find x.

$E = C R$ where R is the *total* resistance in circuit with x in circuit.

$$E = 1 (x + r)$$

where r = resistance of battery, galvanometer and connections with 24 ohms in circuit,

$$E_1 = 1{\cdot}036 (24 + r)$$

with 25 ohms in circuit,

$$E_2 = {\cdot}966 (25 + r)$$

but $$E = E_1 = E_2,$$

$$\therefore \quad 1 (x + r) = 1{\cdot}036 (24 + r) = {\cdot}966 (25 + r).$$

From which we find $r = -10{\cdot}2$, and by substituting this value we find that

$$x = 24{\cdot}4968 \text{ ohms.}$$

Who can imagine a battery with a resistance of *minus* 10·2 ohms, or less, even after deducting the resistance of the galvanometer and connections. Unfortunately, I fear, that there is a slight mistake somewhere, and if it be so it may perhaps be partly excused, as the whole paper is, I think, of a decidedly more practical "tone" than those of former years. I enclose my card, but am compelled by circumstances, although I am not a teacher under the Department, to sign myself as

Un Ingénieur de l'Électricité.